2018

An Action Research Study of Female Calculus Students' Perceptions of the Flipped Classroom Model

Tammy Parham
University of South Carolina

An Action Research Study of Female Calculus Students' Perceptions of the Flipped Classroom Model

by

Tammy Parham

Bachelor of Arts
Winthrop University, 1996

Master of Mathematics
Winthrop University, 1998

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2018

Accepted by:

Susan Schramm-Pate, Major Professor

Nathaniel Bryan, Committee Member

Suha Tamim, Committee Member

George Roy, Committee Member

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

Dedication

I would like to dedicate this work to my parents, Don and Jean Parham, who always supported my pursuit of education, and to my husband, Scott Freshour, for his unending love, patience, and encouragement throughout this endeavor. I am blessed and grateful to have you as my partner on this journey through life.

Acknowledgements

I give my appreciation to God for the many blessings He has bestowed throughout my life and with whom all things are possible. I acknowledge my family, friends, and colleagues who have endured countless conversations about my coursework while providing interesting viewpoints, feedback, and sympathies as needed. In particular, I thank Lauren Adams for sharing in this experience. Without our banter of ideas, laughs, and even tears, I may not have made it out alive. I would also like to recognize the many teachers who have influenced my education and, consequently, my life. And I thank my student-participants and professors whose experiences and expertise have helped to shape my work and my thought processes.

Abstract

To improve teaching practices away from teacher-centered strategies and toward student-centered methodology based in constructivist and social constructivist theory, the present research study describes six female students' perceptions of a flipped-model classroom design in an advanced calculus course. In a flipped-model classroom, there is an inversion of the traditional instructional paradigm to move new content instruction outside of the classroom in order to provide time for student engagement in learning activities and interaction with peers during class meeting time. The flipped model enabled the female students to have more time for collaborative practices and application of calculus material, increased the student-participants' interactions with the teacher-researcher, and required students to take more learning responsibility as they actively engaged with the mathematics content. A qualitative observation design was employed to collect, reflect on, and analyze data as the female students in this advanced calculus course actively learned and collaborated with one another and with their teacher during a four-week unit on limits during the fall of 2017. The primary data set, which included daily informal classroom observations recorded as field notes, was polyangulated with a 20-item questionnaire that was administered mid-way through the advanced calculus limits unit (Mertler, 2014). The data were reflected upon with the six female student-participants following the implementation of the flipped model, during a focus group session at the end of the unit. The student-participants initially experienced unease due to inexperience with the flipped classroom model and expressed their preferences for the

traditional teacher-centered classroom structure to which they were accustomed. However, as the study progressed, they developed satisfaction with some features of the flipped classroom model and were interested in further investigation of the strategies with future lessons with modifications to the original model used for this study. Data analysis resulted in findings that the flipped classroom model provides ways to increase differentiation of instruction, strategies to improve peer-to-peer collaboration and student-to-teacher interaction, methods to increase student responsibility in learning, and ways to vary student engagement with content material. An action plan was designed to continue with a second phase of inquiry in the spring of 2018 with modifications to the flipped model suggested by the student-participants. The action plan includes sharing the findings of both phases with other mathematics teachers at Eagle High School (EHS) in South Carolina during the in-service dates in June 2018. Using the findings from this research, the mathematics teachers of EHS will work in collaboration as a professional learning community to facilitate educational change for underrepresented female students by creating more conducive environments in advanced mathematics courses using active learning strategies made possible with the flipped classroom model.

Keywords: active learning, constructivist pedagogy, flipped classroom, female perceptions, advanced mathematics

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Introduction to Chapter 1

To improve the teacher-researcher's practices towards more student-centered teaching methods based in constructivist and social constructivist principles that can provide underrepresented female students better access and understanding of mathematics by increasing their active learning in mathematics, this study will investigate the intervention of a pedagogical reform called the flipped classroom and female students' perceptions of the phenomenon of the flipped classroom structure in a calculus classroom. Educational reform, grounded in constructivist theory, advocates for a classroom climate that increases active learning and student-centered practices. Studies that will be reviewed in Chapter 2 have argued that the flipped classroom structure can create a student-centered environment to encourage engagement with the content on the part of the learner (Bergmann & Sams, 2012; Chen, Yang, & Hsiao, 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray, Koziniec, & McGill, 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). The flipped classroom model involves a change in teacher practices of content delivery, teacher interactions with students, and student connection with content. In a traditional public school classroom, the introduction is given in class through a lecture and the deeper engagement occurs outside of class through homework (Strayer, 2007), while in a flipped classroom, the introduction occurs outside of class and the engagement occurs inside the classroom. To improve teaching practices to incorporate more active learning strategies, this study is designed to report on

the perceptions of female students – who are typically underrepresented in higher-level mathematics –concerning the phenomenon of the flipped classroom model in their advanced placement (AP) calculus course. The research methods, detailed in Chapter 3, include qualitative methods to examine six female students' attitudes towards the use of the flipped structure in their AP calculus class at EHS (pseudonym), located in the upstate region of South Carolina, using teacher-researcher observations/field notes, questionnaires, and a focus group discussion. Chapter 4 summarizes the data, discusses the findings, and shares interpretations of the data collected. Student opinions evolved from indifference and anxiety at the beginning of the unit due to unfamiliarity with the flipped strategies to increasing confidence and interest in pursuing the flipped model for future lessons after the unit was completed. From the qualitative data emerged themes that the flipped classroom model can provide methods for increasing differentiation of instruction, strategies for improving peer-to-peer collaboration and student-to-teacher interaction, methods for increasing student responsibility in learning, and ways for varying student engagement with content material. The action plan for EHS' calculus classes for future cycles of action research are detailed in Chapter 5. This plan includes a second cycle of individual implementation, data collection, and data analysis by the teacher-researcher using a modification of the flipped classroom model for the spring of 2018, as well as a school-wide plan to share the findings of both phases with the mathematics teachers of EHS during departmental in-service dates in June 2018. The calculus teacher at EHS will collaborate to build a flipped classroom model and create instructional videos and classroom activities for use in the 2018-2019 school year.

Problem of Practice Statement

In the teacher-researcher's AP calculus classroom at Eagle High School in the upstate region of South Carolina, lessons have been taught using traditional behaviorist methodology whereby the teacher lectures during the class time together and the students attempt traditional practice problems independently as homework. The teacher decided to improve her practices by moving toward more student-centered pedagogy grounded in constructivist (Dewey, 1938) and social constructivist ideals (Vygotsky, 1978). The National Council of Teachers of Mathematics (NCTM) created the "Curriculum and Evaluation Standards for School Mathematics" in 1989 to give a direction and plan for reform in mathematics instruction. In that document, which is seminal in mathematics education, the NCTM proposed the creation of "instructional settings that encourage investigation, cooperation, and communication foster problem posing as well as problem solving" (NCTM, 1989; NCTM, 2009). Environments that encourage females to remain in advanced mathematics are described as those in which teachers get to know their students through interaction and students collaborate with their peers on learning tasks (Brown, Ernst, Clark, DeLuca, & Kelly, 2017; Chen et al., 2016). Blending the NCTM reform goals and the information gained from the literature with the teacher-researcher's personal objective to improve classroom pedagogy in mathematics led to the search for a classroom structure that would allow for more active learning and personal interaction in the classroom. Research supports that a flipped classroom organization grounded in social constructivist theory has the potential to provide the NCTM-recommended classroom culture and also to increase student-teacher interaction (Bruner, 1966/2013; Johnson, 2013; Piaget, 1952; Vygotsky, 1978).

Action Research Question and Objective

In order to create a student-centered classroom environment, for underrepresented female students in advanced mathematics, using teaching practices grounded in constructivist and social constructivist principles, the teacher-researcher asks the following: What are female calculus students' perceptions of the flipped classroom model?

Purpose of the Study

The teacher-researcher depended more on traditional behaviorist teaching pedagogy and sought student-centered teaching strategies grounded in constructivist and social constructivist theory to improve her classroom environment in such a way that would engage her underrepresented females in active learning in advanced mathematics. Females are not participating in advanced mathematics at the same frequency as their male counterparts (Boaler, 2002; Hermann et al., 2016; McCrea, 2010; Schaffhauser, 2017). A 1998 report by the American Association of University Women Educational Foundation claims that females fall behind males in mathematics and science and that females participate less than males in class. The NCTM (2009) encourages mathematics teachers to create classroom structures with increased focus on student-centered learning pedagogies. Wiest (2014) suggests the use of student-centered teaching methods as a strategy to support females in science, technology, engineering and mathematics (STEM) courses as well. The goal of this research study is to improve teaching practices by using active learning strategies for females. Studies suggest that an inverted or flipped classroom model, where content is delivered outside of the classroom leaving class time for more student-centered activities, can improve teacher-student interaction, and can

increase achievement (Bottge et al., 2014; Bergmann & Sams, 2012; Chen et al., 2016; Clark 2013; Johnson 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007). Thus, investigating the flipped classroom model as a method for creating a student-centered environment using strategies grounded in constructivist and social constructivist principles for this teacher-researcher's female students will be the focus of this research study.

Mathematics teachers in the school district that includes EHS are encouraged to seek methodologies that improve active learning and increase female participation in advanced mathematics, but no mathematics teacher at EHS had formally employed the flipped model in his or her classroom. Therefore, this research study investigated female students' perceptions of flipped classroom pedagogy in AP calculus. The purpose of this action research study is to examine the phenomenon of a modified instructional setting from a more traditional lecture-then-homework calculus classroom to a flipped classroom structure. Armed with the data from this action research study, the teacher-researcher, in collaboration with her participants and colleagues, devised an action plan to create mathematics classrooms where teaching methods are structured in a way that might better enable female students at EHS to create more meaningful mathematical understanding while encouraging these female students to persist in advanced mathematics.

Scholarly Literature

Theoretical and Historical Context of Flipped Learning

Constructivism. The flipped classroom model, though a relatively contemporary teaching methodology, contains theoretical foundations in the established ideals of constructivism whereby active learners construct knowledge out of their experiences

(Bergmann & Sams, 2012). Constructivism emphasizes active learning and experiences in which students tie prior knowledge to current and future learning as they make meaning of content. Influenced by Dewey (1938), Jerome Bruner (1966/2013) explained in *Man: A Course of Study* that education's goal should not be to merely get something across, arguing that "unless the learner also masters himself, disciplines his taste, and deepens his view of the world, the 'something' that is got across is hardly worth the effort of transmission" (p. 79). Furthermore, he assigns to educators the role of developing experiences that foster deeper understanding for their learners and encourages the organization of curriculum in a spiral approach so students can build on upon what they already know (Bruner, 1966/2013). Likewise, Maxine Greene (1971/2013), in *Curriculum and Consciousness* indicated that for learning to hold meaning for the learner it must involve not just construction, but reconstruction or an interaction of the learner with the material to be learned. Greene's (1971/2013) construction and reconstruction is reminiscent of Dewey's (1938) fundamental principle of continuity in which past experiences influence an individual learner's present experiences, which have the potential to influence future experiences. Greene (1971/2013) goes on to say that "the contemporary learner is more likely than his predecessors to experience moments of strangeness, moments when the recipes he has inherited for the solution of typical problems no longer seem to work" (p. 132). During these moments, the learner must seek new approaches in order to gain personal meaning and relevance.

The theory that education should stem from creating experiences for learners that are engaging, meaningful, and ongoing can be explored through the structure of the flipped classroom. Flipped learning models speak to such an active participation in the

learning experience using an organizational method that allows direct instruction to move outside the classroom and providing an interactive student-centered in-class environment where students are permitted to actively build their learning while relying on their individual experiences to provide context and meaning (Flipped Learning Network, 2014). Keeping in mind the capabilities of the students and the resources available, a flipped model can provide the classroom structure to assist an educator with the design of differentiated experiences that incorporate the active participation of the students in the learning process. Likewise, the flipped learning model relies on a shift from traditional teacher-centered lessons "to a learner-centered approach where in-class time is dedicated to exploring topics in greater depth and creating rich learning opportunities" (Flipped Learning Network, 2014, p. 2). The flipped classroom can provide teachers with a structure in which to build dynamic experiences that allow students to continually review prior lessons and reflect on current learning (Flipped Learning Network, 2014 Bergmann & Sams, 2012). The flipped classroom, as a student-centered model, is rooted in constructivist ideals by allowing students to connect their past knowledge and experiences to their current and future learning and in social constructivist principles by encouraging a cultivation of communal relationships with their peers and teacher (Bergmann & Sams, 2012; Sergiovanni, 1994). Proponents of flipped instruction list the methods benefits as including more creative and effective use of face-to-face class time where there is opportunity for guided, interactive, collaborative, and challenging applications of the curriculum (Herreid & Schiller, 2013).

Social constructivism. Dewey (1938) stated that a teacher should not only assess the needs and abilities of the specific learners, but also arrange the conditions that will

best serve those needs and abilities. Therefore, it is the responsibility of an educator grounding his/her teaching strategies in constructivist educational philosophy to use their surroundings in creating worthwhile experiences (1938). Knowledge about the students or individuals for which one is creating the experiences is a key component for the design of quality experiences that will allow the learner to grow (1938). Gross (2014) argued that girls are more interested in emotional connections due to the release of certain chemicals in their brains. Active learning in this collaborative environment caters to the social and emotional connections that girls value (Gross, 2014).

Vygotsky (1978) social constructivism encouraged the importance of students' social interaction with their instructors and their peers in the co-construction of new knowledge. He described a "zone of proximal development" as the difference between what a learner can achieve independently and the more encompassing space of what a learner can achieve while making meaning with the assistance of peers or a teacher (Vygotsky, 1978, p. 37). Once again, the flipped classroom model unites these ideals with a shift from students "being the product of teaching" to students being "the center of learning, where they are actively involved in knowledge formation through opportunities to participate in and evaluate their learning in a manner that is personally meaningful" (Hadman, McKnight, McKnight, & Arfstrom, 2013, p. 5).

When seeking a teaching framework where female subjects can be taught in a manner that connects to their personal interests and talents while incorporating tailored experiences using available resources, literature pointed to the flipped classroom model (Flipped Learning Network, 2014). The flipped classroom is an evolving pedagogy that can incorporate cooperative class activities, differentiate learning, and increase

interaction. It can also include a mastery element permitting students to bring their personal experiences and prior knowledge with them to further develop their learning at an individual pace (Bergmann & Sams, 2012). Flipped methodology is said to provide the opportunity for greater interaction between teachers and students, which should result in a better consideration of the needs of female students. Flipped learning model pioneers Bergmann and Sams (2012) suggested that increased teacher-student interaction results in better teacher-student relationships. Aligning with the social constructivist ideals of Vygotsky (1978) the flipped model allows for a classroom organizational method in which knowledge is created and is continually and collaboratively grown out of students' attitudes, experiences and efforts (Flipped Learning Network, 2014).

Active student-centered learning. Dewey (1938) suggested that learning experiences are centered on the student and not the teacher, and stated that the main purpose of the educational institution is to "prepare the young for future responsibilities and for success in life, by means of acquisition of the organized bodies of information and prepared forms of skills which comprehend the material of instruction" (p. 18). Armed with this purpose, educators should seek methodologies that engage their students in the content at hand as well as equip their students with skills they can carry with them beyond the classroom. Dewey (1938) recognized the essential role that quality experience should play in education, while asserting that educational experiences should involve "continuity and interaction between the learner and what is learned" (p. 10). In his seminal work, *My Pedagogic Creed*, Dewey (1929/2013) described the teacher's role in education as more than simply doling out information. Teachers should rather be training students regarding what to do with the accessible information. He also stated that

"education must be conceived as a continuing reconstruction of experience" (p. 37). We have a present and future that is less dependent on acquiring information and more dependent on filtering, evaluating, analyzing and composing available information in ways that prove useful for upcoming endeavors. It is necessary to train our students, particularly the female students who have historically received less academic attention, in the skills of designing and engineering innovative ideas. Under the constructivist theory, knowledge is not fixed and is never fully learned, but is grown through dynamic experiences and should have an emphasis on active learning. A traditional classroom where students sit at desks and passively receive direct instruction does not achieve these goals.

Similarly, Noddings (1983/2013) suggests that "there is more to life, more to excellence, more to success, and more to devotion than can be captured in a single intellectual model of excellence" (p. 191). Noddings elaborated on that belief, saying: "It is not the subjects offered that make a curriculum properly a part of education but how those subjects are taught, how they connect to the personal interests and talents of the students who study them, and how skillfully they are laid out against the whole continuum of human experience" (p. 193).

Stigler and Hiebert (1999) also suggested that when teaching mathematics, educators should "generate opportunities for students to be actively involved in their learning" and "help students be self-directed learners with the ability to monitor and adjust their approaches to learning" (p. 10). Adler (1988) argued that the purpose of education is to create learners, thinkers and problem solvers.

The flipped classroom model relies on a shift from traditional teacher-centered lessons "to a learner-centered approach where in-class time is dedicated to exploring topics in greater depth and creating rich learning opportunities" (Flipped Learning Network 2014, p. 2). The flipped classroom structure addresses active learning by creating a student-centered culture in which students are required to go beyond the typical passive consumption of information, and instead are expected to actively filter, analyze and digest information, then create, construct, collaborate and/or apply their knowledge in an atmosphere of support from their peers and their teachers rather than in isolation at home. These skills will better serve students in a world where so much information is readily available due to the accessible technology and in a world where the assimilation of knowledge is a superior and more marketable skill than the mere acquisition of information. McLaughlin et al. (2014) flipped a first-year pharmaceutics course at the University of North Carolina Eshelman School of Pharmacy, noting in their results that the flipped approach "provides instructors with opportunities to engage a wide range of learning styles and implement pedagogies that encourage problem solving during dedicated class time" (p. 2). They also stated that in-class open-ended active learning exercises "equip students for success by fostering critical cognitive development and promoting innovation through collaboration" (p. 2). When basing teaching practices in constructivist and social constructivist philosophy, the educator's role is not to be a provider of knowledge, but to be the creator of student-centered experiences that allow learners to co-develop and redevelop his understanding using his own perceptions and the teacher as a guide and a resource.

Technological resources. In Franklin Bobbitt's (1918) work *The Curriculum*, he noted that current educational practices were formed for a time other than the current day. He also stated that "as the world presses eagerly forward toward the accomplishment of new things, education also must advance no less swiftly" (p. 11). Therefore, in this new age of information and technology, teachers should evaluate their pedagogy and seek effective methods to develop the abilities of all their students – particularly any underrepresented groups such as female students in mathematics – to think actively and to use life experiences and available technological resources.

One way to use existing technology is by employing a flipped learning model in which students watch instructional videos outside of class time in order to use in-class time for student-centered exercises with the teacher as a face-to-face resource. The flipped classroom consists of two components: an automated component that uses computer technology such as video lecture for out-of-class activities, and a component requiring collaborative interaction for the in-class activities (Bishop & Verleger, 2013). When using instructional videos for content delivery, today's flipped classroom educator has a variety of options from which to choose. A teacher may decide to record his or her own videos, which would lend a personal touch, but there are also many massive open online courses and other sources of free online videos from platforms including YouTube, the Khan Academy, MIT's OpenCourseWare and other similar sources (Brame, 2013). Thus, teachers would be remiss to ignore the wealth of tools that can be used to best serve their students.

Additionally, Bergmann and Sams (2012) wrote that "flipping allows teachers to leverage technology to increase interaction with students" (p. 25). The flipped classroom

model recognizes that students can acquire new information or content from sources other than face-to-face direct instruction from the teacher in order to use the classroom time in more constructive and collaborative ways. Furthermore, EHS started a one-to-one technology initiative in the 2014-2015 school year in which each student was provided with an Apple MacBook Air computer for school and home use. Using the available technology to move the direct instruction out of the classroom, teacher-student time together is used to guide students through educational experiences based on student needs and to supervise the practical application of previously acquired knowledge.

Glossary of Key Terms

The following operational definitions were used to describe terms for this study.

1. *Active learning:* Active learning is a process in which students engage in activities such as reading, writing, discussion, or problem solving that promote analysis, synthesis, and evaluation of class content (Center for Research on Learning and Teaching, 2016).
2. *Advanced placement (AP)*: Advanced placement (AP) is a program offered by the private, nonprofit corporation known as the College Board, offering college-level curricula and examinations to high school students. Colleges and universities may offer course credit to students who obtain high scores on the AP examinations (College Board, 2016).
3. *AP calculus*: An AP calculus course is a course that is roughly equivalent to a first-semester college calculus course devoted to topics in differential and integral calculus. The AP course covers topics in areas including

concepts and skills of limits, derivatives, definite integrals, and the fundamental theorem of calculus (College Board, 2016).

4. *Constructivism:* Constructivism is an educational theory positing that individuals learn by constructing their own understanding and knowledge of the world through experience and reflection (Palincsar, 1998).
5. *Coursera*: Coursera is an education platform that partners with universities and organizations worldwide to offer online courses for anyone to take. (Coursera n.d.)
6. *Flipped classroom model/blended classroom/inverted classroom*: The flipped classroom model (also referred to as the blended classroom or the inverted classroom) is an instructional setting in which students are introduced to new content outside of the face-to-face classroom and use in-class time to ask questions, work problems, communicate about their learning, collaborate with peers, and interact with the teacher. In this setting, the tasks that students have traditionally done at home become the tasks that they do in class, and vice versa. The setting "flips" the traditional understandings of classwork and homework (Bergmann & Sams, 2012; Brame, 2013)
7. *Khan Academy*: The Khan Academy is a non-profit educational organization that provides free video tutorials and interactive exercises (Khan Academy, 2016).
8. *MIT OpenCourseWare*: MIT OpenCourseWare is an initiative of the Massachusetts Institute of Technology (MIT) to put all of the educational

materials from its undergraduate- and graduate-level courses online and to make them available free of charge (MIT OpenCourseWare, 2016).

9. *Massive open online course*: A massive open online course is a model for delivering content free online to any person who wants to take a course (Educause, 2016).
10. *Social constructivism*: Social constructivism can be considered as the interdependence between individual and social processes in learning and development (Palincsar, 1998).
11. *STEM*: STEM is an acronym that stands for the subject areas of science, technology, engineering, and mathematics, referring to the subject areas collectively.
12. *Traditional classroom model*: The traditional classroom is one in which initial exposure to content occurs via lecture in the classroom, with students assimilating knowledge through homework (Brame, 2013).
13. *YouTube*: YouTube is a video sharing website (Wikipedia, 2018).

Potential Weaknesses

Assumptions

The researcher assumed that the students would regularly participate in the viewing of the lessons prior to class so they could work with their group members during class time. However, some students did not complete the out-of-class assignments. The flipped classroom model can be modified to provide motivation for completing out-of-class viewing of the instructional videos by using measures such as pre-class assessments that hold students accountable for out-of-class material. The teacher-researcher also

assumed that the students would prefer working together collaboratively, but some students would have preferred to work independently on some assignments. Some flipped models allow for independent work, so if the model were to be the primary strategy for an entire course, opportunities for independent work would be beneficial when combined with collaborative activities.

Limitations

Serving as an insider to the action research study, the teacher-researcher made and reflected on decisions throughout the inquiry, facilitated activities in the classroom, and was able to gain first-hand knowledge of how the flipped lessons affected the student-participants' conversations about mathematics. In the position of an outsider, the teacher-researcher collected, analyzed, and interpreted the data to answer the research question. Maintaining the dual positions as both inside and outsider, the teacher-researcher had to avoid bias and prevent influence on the student-participants' perceptions of the flipped classroom model (Herr & Anderson, 2005). Some students may have attempted to give responses that they believed would please the teacher-researcher. During data collection, the focus group did provide more in-depth insights into the reasons behind some of the female students' unfavorable experiences with the flipped model, but this collection method can also discourage less confident participants from sharing their opinions if their opinions differ from those of other group members (Dana & Yendol-Hoppey, 2014). Also, the small size of the population served as a limitation for this study. However, this study did provide some information concerning the students' perceptions of the flipped classroom model for the design of future learning experiences for this particular course.

The four-week time frame for the calculus unit could also be perceived as a limitation. A longer study could have provided the opportunity for additional data.

Significance of the Study

A review of recent literature reveals a gap in the research on the topic of the flipped classroom models in rural high-school settings, and particularly with female students in mathematics. This study adds to the literature on the flipped classroom model by examining the phenomenon of the flipped classroom for female students in AP calculus in a rural high school in South Carolina.

Teaching requires flexibility and adaptability in a changing field. Teachers can choose to participate in the evolution of their profession through action research that reflects on what works, identifies areas that need improvement, collects and analyzes data, reflects on the data, and devises an action plan (Mertler, 2014; Mills, 2014). Action research should be an unending cycle throughout the career of any teacher.

Unlike traditional research methods, action research is not designed for generalizability and there is no need for specific contextual information for the purposes of replication. However, it is important to provide a context for the unique, specific, and local situation in which the action plan will be executed. In this case, the study was implemented in the Eagle school district (pseudonym) in the upstate region of South Carolina, in a high school with an enrollment of more than 2,100 students. Annual enrollment in calculus courses at Eagle High School, including the honors and AP level, is approximately 100 total students. Many of the transplants to this geographic area choose this location because of the history of academic success of the Eagle school district.

This action research study focused on improving the classroom practices of the teacher-researcher to include student-centered strategies that are informed by constructivist and social constructivist principles and that aimed to encourage active learning on the part of the female students in an advanced calculus course. The study occurred at Eagle High School in the fall of the 2017-2018 school year, in AP calculus courses that met for 90 minutes each day during the 180-day school year. The six females chosen as study participants were all Caucasian, lower- to middle-class, high-achieving students. All of the young women were actively involved in extra-curricular activities, clubs, and sports. Each participant is described in more detail in Chapters 3 and 4.

In 2014, EHS began a one-to-one technology initiative in which each student was issued an *Apple MacBook Air* to use for educational purposes during the school year. This available technology was used to assist with implementing a flipped classroom for the AP calculus class. All students indicated that they had access to the Internet at their homes.

Teacher-researchers can employ action research as part of their efforts to improve their pedagogical practices. After reflecting on current classroom methods, a teacher can identify a topic or problem of practice. In this case, the topic was limited to the use of a student-centered teaching strategy in order to create a mathematics learning environment in which female students could actively and collaboratively construct meaning of the mathematics concepts being taught. The researcher conducted preliminary research on current practices that involved active learning for students, and engaged in conversations with students, colleagues and the district mathematics instructional specialist, determining from those resources that a flipped classroom model should be employed in

a qualitative action research study aimed at discerning female students' perceptions of the flipped classroom. Because scheduling issues made it impossible to randomize the selection of student participants, the researcher incorporated a phenomenological qualitative design into the study (Mertler, 2014). After securing the proper permission from the participants, the students were taught the calculus standards regarding limits through the use of video lessons that the students watched outside of class time. Class time was devoted to partnered and small group assignments, allowing access to the teacher for assistance and clarification of topics. The researcher collected data in the form of informal classroom observations, field notes, questionnaires, and a focus group, gathering information regarding students' opinions of the flipped classroom strategies employed in the study. Questionnaire data were subjected to quantitative analysis to support the thematic analysis of the qualitative data gained from the observations, notes, questionnaires, and the focus group. Findings indicated that the flipped classroom model yields benefits including increased differentiation of instruction, improved peer-to-peer collaboration, increased student-teacher interaction, improved student responsibility for learning, and more varied student engagement with content material. After analysis of the data, the teacher-researcher shared the results with the participants as well as with her colleagues in the mathematics department. Student attitudes about the flipped model shifted throughout the course of the study, with students indicating on the mid-unit questionnaire that they initially preferred a teacher-centered lesson, and then reporting during the focus group that they eventually came to appreciate the collaborative classroom activities. Through reflection with her student participants and with the input of her peers, the researcher developed an action plan to incorporate lessons using the

flipped classroom model in future calculus courses at EHS. The researcher did not aim to create generalizable results, but rather set the goal of addressing the local and specific problem of providing an active environment grounded in constructivist ideals for female students in advanced mathematics. Action research methods and continual reflection provided the opportunity to monitor and revise the study as needed during the process. Throughout the study, the teacher-researcher critically reviewed the original purpose, revised the action research question, adjusted the design of the study, and modified the process of data analysis to ensure her study was appropriate for addressing the problem of practice. The teacher-researcher also engaged in a final reflection in order to determine how this study immediately influenced teaching practices and to determine studies that might be needed when moving forward to make positive educational change.

Overview of the Study

The teacher-researcher set out to improve teaching practices by creating a more student-centered environment, choosing to employ the pedagogical strategy referred to as the flipped classroom model. The flipped classroom model offers an alternative classroom structure that can address differentiation in instruction, and increase active learning by rearranging the content delivery and content application for a course, potentially providing greater access to advanced mathematics concepts for female students.

Chapter 1 provided an introduction to the action research study, provided theoretical groundings, historical contexts, and academic underpinnings for the flipped classroom model, explained the problem of practice in the context of the particular classroom setting, and described the purpose of this study and its alignment with the

research question. The chapter also defined key terms and discussed the study's assumptions, limitations, and significance.

Chapter 2 provides a review of the relevant literature addressing the following themes: the constructivist and social constructivist theories of learning, active learning, differentiation of teaching strategies to address female students' learning styles, and origins of the flipped classroom model. Chapter 3 details the research methodology used for this qualitative study. Chapter 4 contains a presentation of the data, an explanation of the data analysis, a report of the findings of the study, and an interpretation of the results. Chapter 5 presents the conclusions of the study and offers future recommendations, including an action plan for future cycles of action research.

Chapter 2: Literature Review

Introduction to Chapter 2

Mathematics classrooms at EHS typically rely on traditional pedagogical strategies, with students participating as passive learners in a teacher-led lecture environment. To increase active learning strategies and improve the student-centered classroom setting for underrepresented females in advanced mathematics, the teacher-researcher investigated students' perceptions of the flipped classroom model in the school's AP calculus courses. The flipped classroom model shifts the classroom from the traditional paradigm of classroom content delivery and independent application and practice to a model in which students learn their prescribed curricular content outside of the four walls of the classroom and use their allotted class time for exploration, practice, application and increased interaction with teachers and classmates. The teacher-researcher used the flipped model to incorporate active participation of the students in the learning process.

In Chapter 2, the teacher-researcher reviews existing literature to describe the foundations of the flipped classroom model under the framework of constructivism, social constructivism, active learning, and differentiation of teaching strategies for female students, and includes a summary of the origins of the flipped model. Chapter 2 also includes studies investigating students' perceptions of the phenomenon of the flipped classroom structure and a description of the modeled design of this action research study (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-

Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). The importance of active learning and collaboration when constructing learning, especially for females, is reported in the scholarly literature described in this chapter, along with a discussion of the benefits and limitations of the flipped models.

Problem of Practice

Mathematics teachers at EHS have relied on traditional teacher-centered teaching strategies, which do not address the active learning methods that encourage underrepresented females to make meaning of mathematics in a collaborative setting. The NCTM (2009) encourages mathematics teachers to focus on increasing student-centered learning pedagogies. Studies suggest that an inverted or flipped classroom model, with content delivered outside of the classroom leaving class time for more student-centered activities, can increase student engagement and improve teacher-student interaction (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). Thus, investigating female students' perceptions of the flipped classroom model in AP calculus was the focus of this action research cycle.

Statement of Purpose

The primary purpose of this action research study was to investigate the flipped classroom model as a strategy for improving practices and moving toward student-centered methods grounded in constructivist and social constructivist theory that can provide female students with better access and understanding of mathematics by increasing their active learning in the calculus classroom. To that end, the action research

gathered the perceptions of six female FHS students regarding the phenomenon of the flipped classroom model.

Action Research Question

In order to examine one specific student-centered classroom environment informed by constructivist and social constructivist principles for underrepresented female students in advanced mathematics, the teacher-researcher asks the following: What are female calculus students' perceptions of the flipped classroom model?

Structure of the Literature Review

This literature review was organized around describing the constructivist and social constructivist theories of learning, active learning, and differentiation of teaching strategies for female learners, as well as explaining the origins of the flipped classroom structure and its potential benefits and limitations as noted by previous studies of implementing flipped lessons. The literature on the use of the flipped classroom model is continuing to expand, with new articles and texts available on best practices and flipped model variations. Empirical research in this area is limited, but new research continues to emerge as interest grows about the potential of this instructional method. Though the quantity of literature concerning the flipped classroom model is growing, there are gaps that merit further investigation. For instance, Roshan and Roshan (2012) reported using the Flipped methodology in an AP calculus course, the researchers did not formally collect data on the effects in this specific subject area. The study also focused on a private school located in an affluent community in Potomac, Md. (Roshan 2012), in contrast to this action research study, which focused on a public high school setting in rural South Carolina. There is room for future studies in the area of flipped classroom methodology;

for example, regarding the flipped classroom perceptions of low-achieving students, regarding student academic gains in a rural setting when using the flipped model in place of a traditional classroom model, or regarding students' opinions of using teacher-made materials and videos versus online materials from another source when implementing the flipped model.

In addition to providing a greater understanding of the flipped model in terms of the constructivist and social constructivist ideals and active learning and differentiation strategies, the literature described findings from previous studies in high school biology, (Knight & Wood, 2005), college-level statistics (Strayer, 2007), high school pre-calculus (Johnson, 2013), and introductory college Calculus (McGivney-Burelle & Xue, 2013).

Conceptual Framework

This action research cycle focused on six female students in an AP calculus classroom at EHS in South Carolina. The research focused on the problem of practice regarding the current choice of teacher-centered methodologies as the primary teaching strategies. The action research purpose was to implement a flipped classroom model in the calculus class for the six female students, and to investigate the students' perceptions of the model. The teacher-researcher used qualitative data collection methods such as daily classroom observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus group to answer the specific action research question: What are female students' perceptions of a flipped classroom model in an AP calculus classroom at EHS? Various theorists and previous studies served as guiding and grounding principles for this action research study. A visual relationship of the research site and participants, the

problem of practice, the purpose statement and action research methods, the research question, and the key contributors of relevant literature is provided below in Figure 2.1.

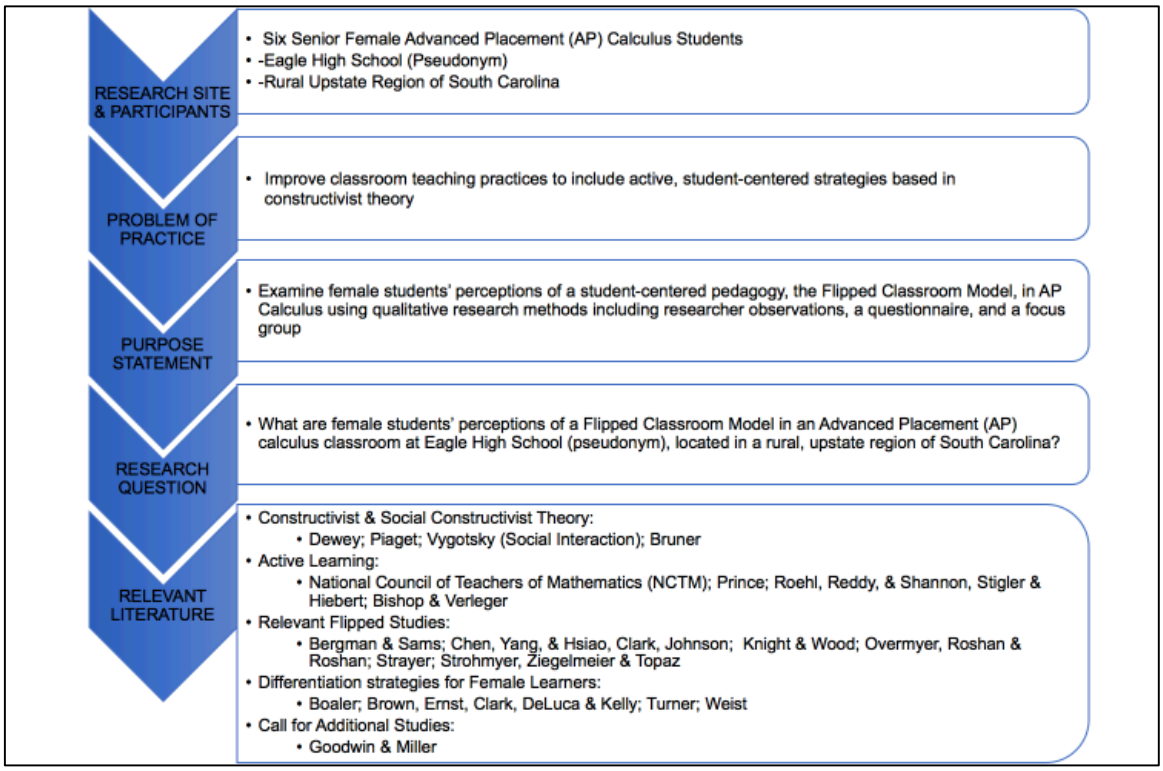

Figure 2.1. Conceptual Framework for the Action Research Study

Themes and Ideas

Constructivist and Social Constructivist Theories of Learning

The roots of constructivism lie in the learning theories of Dewey (1938), who indicated that prior experience is vital in the development of new knowledge and that students should be engaged in the creation of knowledge. Other educational theorists – specifically Vygotsky (1978), Piaget (1952), and Bruner (1966/2013) – built on the early teachings of Dewey to develop the principles of constructivism to include learning as an active process of building knowledge through social negotiation based on personal experiences. Piaget (1952) followed Dewey's (1938) philosophy that the construction of

knowledge is a cyclical building process during which prior experiences form the basis for new ideas, and in which taught skills should be dependent on the developmental stage of the learner. Vygotsky (1978) further developed social constructivism using the social aspect of learning through which students make meaning and co-construct knowledge in collaboration with one another, with teachers serving as guides. Vygotsky explained that there is a level of knowledge development at which a student has attained independent success, and there is a greater level of knowledge development that a student could potentially attain in collaboration with fellow learners or with guidance from teachers. Vygotsky (1978) referred to the space between these two levels of knowledge development as the zone of proximal development. Like Vygotsky, Bruner's (1966/2013) principles of constructivism relied on social interaction and communication for learners to build their knowledge through active dialogue. While the three theorists were not of one mind on every aspect of the learning theory, as followers of constructivism, they all concurred that learning is not achieved when students are passive recipients, but is achieved when learners are active participants who filter knowledge through the context of their own experiences. The social constructivist theory holds that students should engage with the content as it relates to their personal experiences and make meaning of the content as they grow their understanding collaboratively as a community of learners that interact and negotiate with one another as teachers play guiding roles.

Active Learning

Active learning is defined as "any instructional method that engages students in the learning process" (Prince, 2004, p. 223). This learning theory stands in opposition to the traditional teacher-centered classroom in which the teacher lectures while students

passively receive the taught information. Active participation depends on student efforts to engage in the process of making meaning for themselves using higher-order thinking skills (Roehl, Reddy, & Shannon, 2013). Educators can restructure their classrooms using different pedagogies that move the focus from teacher to learner and require student construction of knowledge while teachers serve in guiding roles (Strayer, 2007). Berrett (2012) reports "as sources of information grow more plentiful, simply transmitting information should not be the focus of teaching; helping students to assimilate that information should" (para. 32). Teachers should develop experiences that will entwine their subject-related curricula with life skills that will serve all of their students beyond the scope of their coursework. Creating activities that foster students' abilities to seek knowledge, analyze information, construct a theory, enact a plan, work cooperatively, communicate and reflect can promote the skills desired for an intellectual life (Eisner, 2001/2013; Noddings, 2007/2013).

Mathematics, in particular, needs to move from abstract concepts to concrete application through connection of individual experiences and construction of learning (Courant & Robbins, 1941/1996). For students learning mathematics, in-class experiences should include posing and solving problems since help is available peers or instructors (Berrett, 2012). Teachers can use many tools to teach, depending on their content, students, cultures, and available resources, and the flipped model is a tool that allows teachers to exchange passive environments for active student learning (Flipped Learning Network, 2014; Bergmann & Sams, 2012). Bishop and Verleger (2013) explained that the active learning component is a crucial piece of the flipped classroom.

Differentiation of Teaching Strategies to Address Female Students' Learning Styles

Males have consistently outnumbered females in AP mathematics courses, though there are no documented, innate differences in mathematical ability between the sexes (Hanna, 2008). The burden of change is not on female students, but on advanced mathematics educators, who must seek specific teaching strategies to break social and cultural barriers in order to provide equitable attainment opportunities for female learners. Research shows, for example, that competition does not facilitate female learning, but that cooperative and collaborative environments positively impact female learning (Turner, 1995). Turner recommended that mathematics teachers work to create classroom cultures where originality, independent, and creative thinking are valued to address differences in learning styles of females. Boaler (2002) and Wiest (2014) called for the mathematics education reform movement to include the creation of experiences that bring curriculum to life in the classroom with student-centered teaching methods. Boaler explained that girls are unsatisfied with mathematics in a setting that relies on traditional pedagogy, but thrive when the exploration of mathematical ideas is encouraged. Brown et al. (2017) recommended that teachers adapt their teaching methods to foster student interaction, provide choice, and invoke creativity and motivation to better serve their female students' cognitive styles. The reformation of teaching practices to more collaborative, hands-on creative and less competitive methods and the restructuring of learning environments to more open-ended and supportive surroundings can aid in the recruitment, success, and retention of females in advanced mathematics (Brown et al, 2017).

Origins of the Flipped Classroom Model

According to the Flipped Learning Network (2014) the flipped learning methodology is defined as:

> A pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter. (p. 1)

This definition allows for great variety in the way that flipping is implemented. Inverted, reverse, blended, and hybrid instruction are additional terminology associated with flipping and with the mindset of creating a learning culture that is more student-centered through the integration of face-to-face and online learning (Swan, 2009).

Bergmann and Sams (2012) focused on a rural Colorado high school, seeking a solution to the problem of students missing class and crucial content as a result of long-distance travel for extracurricular competitions. The researchers began recording their chemistry lessons and posting them online for students to view. Other instructors had used videos to assist with instruction, but Bergmann and Sams (2012) are recognized as pioneers in the flipped methodology (Ash, 2012). Since the early days of recording full lectures and posting them for student viewing, Bergmann and Sams (2012) went on to perfect their flipped classroom model by including a mastery component that allowed for a more differentiated and self-paced curriculum. The flipped movement demonstrates a shift in mindset from a more traditional model to one that is more consistent with the

constructivist theory, in which students create their own understanding based on prior knowledge through active learning experiences (Bruner, 1966/2013; Vygotsky, 1978).

Bergmann and Sams (2012) explained that "flipping the classroom establishes a framework that ensures students receive a personalized education tailored to their individual needs" (p. 6). As educators, they sought to solve the problem of students missing significant portions of classes as a result of being dismissed for long-distance travel to extra-curricular competitions. Student absences, coupled with the realization that students come to class with divergent background experiences and abilities, inspired Bergmann and Sams (2012) to pursue alternatives to their traditional classrooms. In their traditional classroom environments, students received information from the teacher during class time and then applied it outside of class using labs and projects to reinforce ideas. Bergmann and Sams (2012) began by recording their lessons for absent students, eventually using the recordings for all students. By using the videos to deliver content to their students outside of class time, they discovered they had more time for student-centered activities in class and were able to increase their interaction with students. For their part, students were learning more and were able to better personalize their understanding. The flipped classroom model rejects one-size-fits-all classroom proposals, instead presenting a structure providing for more personalized and differentiated curriculum and for active learning.

Points of View

Benefits of Flipped Classrooms

Goodwin and Miller (2013) noted that as of the time of their research, there was no scientific research basis for the effectiveness of flipped classrooms, but that some

nonscientific data suggested that the model was beneficial. For instance, they (2013) reported the following data:

> In one survey of 453 teachers who flipped their classrooms, 67 percent reported increased test scores, with particular benefits for students in advanced placement classes and students with special needs; 80 percent reported improved student attitudes; and 99 percent said they would flip their classrooms again next year. (p. 78)

Bergman and Sams (2012) pointed to other advantages of employing a flipped structure, including improved student-teacher interaction, opportunities for real-time feedback, increased student engagement, more self-paced learning and more meaningful homework. In fact, Bergmann and Sams (2012) argued that flipped classrooms "speak the language of today's students" (p. 20), who are "accustomed to turning to the web and social media for information and interaction" (Goodwin & Miller, 2013, p. 80). Proponents of inverted instruction also listed benefits including more creative and effective use of face-to-face class time with the opportunity for guided, interactive, and challenging applications of the curriculum (Herreid & Schiller, 2013). And Horn (2013) claimed that providing students with the option or watching instructional material when and where they choose gives them the ability to go back to review sections of the lesson or more forward past areas they understand, giving them "greater ownership over their learning" (p. 78). Laursen, Hassi, Kogan, and Weston (2014) found that active learning strategies resulted in positive impacts on student outcomes, especially for women.

Pearson Education, Inc. (2012) reported a successful experiment with flipping a mathematics classroom in Minnesota, noting that the teacher said his students "were

actively doing mathematics rather than passively watching [him] do mathenatics on the interactive whiteboard" (para. 4). After three years using the flipped classroom model in the Minnesota classroom, student scores in mathematical proficiency were consistently higher than those from the previous years of using the traditional lecture structure. In each level of mathematics, students who learned in the flipped model setting outscored those from the traditional model. The teacher reported that the school's students now take higher-level mathematics courses as a result of their increased proficiency (Pearson Education, Inc., 2012).

Flipped classrooms are improving student outcomes, and are also improving critical thinking, creative problem solving, higher-order thinking, and professional skills among student participants. Students involved in flipped classrooms also show improved team skills and peer-to-peer interaction, demonstrate more student-centered learning, and benefit from enhanced teacher-student interaction (Aronson, Arfstrom & Tam, 2013). The flipped classroom model provides a format that frees up classroom time for teacher-developed, student-centered activities that encourage the active "transfer of learning" and give students the training to "deal with problems and issues outside of the classroom" (Eisner, 2001/2013, p. 283). Eisner contended that "the function of schooling is not to enable students to do better in school. The function of schooling is to enable students to do better in life" (p. 281).

Limitations and Criticisms of Flipped Classroom Culture

Research indicated that initial implementation of the flipped classroom model will likely face challenges. For one thing, the availability of the necessary technology for students to access and watch the videos outside of class time requires consideration.

(Renfro, 2014). Furthermore, modifying the classroom framework from traditional to flipped requires educators to allocate more time for class preparation. Teachers who try flipping report that the move requires significant amounts of extra time for recording and editing the videos, selecting pre-recorded videos, preparing methods to hold students accountable for their homework and to assess the work done at home, and developing in-class experiences to effectively use the face-to-face class interactions with students (Herreid & Schiller, 2013).

The flipped classroom model also requires a change in mindset on the part of the both teachers and students. An important element of implementing a new teaching strategy is the establishment of trust between the teacher-researcher and the student-participants, with students being assured that the teacher is looking out for their best interests and seeking to create a more beneficial, student-centered classroom environment. Without establishing this trust, students may be resistant to flipped classes, objecting to encountering new material for the first time at home instead of through interaction with the teacher (Herreid & Schiller, 2013). Students may feel as if they have been abandoned to learn new content on their own (Talbert, 2012). Voigt's (2016) study of a flipped undergraduate, pre-calculus course reported a significant difference between genders in the response to flipped classrooms, with three times more female students than male students indicating they would not recommend the flipped format. Students may also be reluctant to take increased responsibility for their education, and need training regarding the new expectations of the flipped classroom structure (Herreid & Schiller, 2013).

Incorporating a flipped class structure allows for a redefining of what is accomplished in the classroom, thereby transforming the type of learning that can occur.

However, Ash (2012) reported that the concept of flipped classrooms faces some criticism. In his study, one participant expressed his concern that "if you're still relying on lecture as your primary mode of getting content across, you haven't done anything to shift the type of learning that's occurring" (Ash, 2012, p. 2).

Summaries of Literature

McGivney-Burelle and Xue (2013) researched a flipped classroom because they assumed that "students require less support when engaged in learning definitions, basic facts, skills and routine procedures, and require more instructor feedback when they are engaged in activities that involve higher-level reasoning" (p. 478). Noting that calculus is a gateway course for students entering into STEM fields, the researchers focused their study on a flipped calculus unit, comparing it to another section of the same class taught with traditional lecture methods (McGivney-Burrelle & Xue, 2013). Based on their analysis of exam results from the two classrooms and on a survey that gathered data about student perceptions of the flipped unit, they reported finding "some evidence that students learning via a flipping pedagogy outperform students who are in a traditional lecture," and concluded that their students were "very satisfied with the simple videos/screencasts" they created (p. 484). While admitting that the tasks of creating, editing and posting the videos and developing in-class quizzes and problem sets was time-consuming, McGivney-Burrelle and Xue (2013) concluded that their "flipping pedagogy in calculus was effective and worth the significant investment of faculty time and effort" (p. 485). Additionally, they reported that the students in the flipped section of calculus "preferred this type of pedagogy, particularly the availability of videos and the use of class time to solve problems, and fared better on homework and tests" (p. 485).

McLaughlin et al. (2014) focused on a flipped first-year pharmaceutics course at a North Carolina university. Their findings showed that the flipped model "provides instructors with opportunities to engage a wide range of learning styles and implement pedagogies that encourage problem solving during dedicated class time" (p. 2). They also stated that in-class, open-ended active learning exercises "equip students for success by fostering critical cognitive development and promoting innovation through collaboration" (p. 2).

In response to the NCTM (1989; 2009) challenge to shift away from traditional lecture and toward more engaging instruction, Johnson (2013) reported results from flipping a flipping pre-calculus class and foundations/pre-calculus classes. Johnson (2013) described that students enjoyed learning in the flipped classroom structure. Though the stated purpose of his research was to determine students' perceptions about the flipped classroom he reported also being "satisfied with student achievement, experiencing a significant increase in [his] student's provincial exam scores compared to the previous semester when [he] did not flip [his] classes" (p. 8). He offered the flipped classroom as a solution to "allow children to learn mathematics and other subjects in a progressive environment where thinking critically can be supported using 21st century tools" (Johnson, 2013, p. 14).

Knight and Wood (2005) produced similar results in a study of upper-level biology courses at a Colorado University in which more dynamic activities were incorporated in the classroom. The researchers moved lectures and reading out of the classroom for some of the classes, but kept a more traditional environment for others. They concluded that students in the interactive classes showed significant improvement

in their problem-solving skills compared to students in the lecture-based classes (Knight & Wood, 2005).

Clark (2013) reported favorable student responses to the flipped classroom model in an Algebra I class, and Day and Foley (2006) reported strong positive attitudes toward a flipped classroom in their college-level Introductory Human-Computer Interaction course. However, Strayer (2007) reported less satisfaction on the part of students in a flipped college statistics course, with the students expressing dissatisfaction regarding the degree to which the structure of the class prepared them for their learning tasks and reporting that the variety of in-class activities left them feeling lost. Renfro's (2014) undergraduate calculus students indicated their preference for direct teacher-led instruction. Other studies reported mixed feelings throughout their studies, including Roshan and Roshan (2012), who reported that their AP calculus students were initially unsure about the flipped strategies, and Ziegelmeier and Topaz (2015), who described some students as having positive feelings about the strategies and others as having negative feelings about them.

Variables or Themes

The variables and structure of this action research study were modeled on studies by Ziegelmeier and Topaz (2015), Clark (2013), and Johnson (2013) that focused on student performance and perceptions of flipped classes. The teacher-researcher for this current study acquired permission for the study in the form of a letter of consent, and then proceeded to implement the teaching strategies associated with the flipped classroom model for one calculus class. During the calculus unit on Limits, the six participating female students were instructed to watch video lessons chosen by the teacher-researcher

from the YouTube library, to take notes, and to write questions on the lessons prior to the class meeting. Class time was spent in an active-learning setting with the female students clarifying the concepts presented in the videos and collaboratively participating in the co-construction of knowledge about calculus limits through problem solving, sharing solutions, and completing practice problems with partners or small groups. The students had direct access to interact with the teacher throughout the class period. The teacher-researcher collected data in the form of informal classroom observations recorded as field notes, answers to questionnaires, and responses during a focus group session designed to elicit responses from students regarding their perceptions of the class format. For this action research study, the gender of student participants was determined by the classification in the high school registrar's database, which reports the students' or parents' identification of student gender. Participating students also indicated their gender on student information sheets at the beginning of the school year.

Primary and Secondary Sources

The teacher-researcher sought peer-reviewed scholarly journal articles as primary sources for the literature review. Published dissertations and studies relating to the flipped classroom model served as models from which to build the classroom strategies and methodology for this action research cycle (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Strayer, 2007; Ziegelmeier & Topaz, 2015). Theorists such as Dewey (1938), Piaget (1952), Vygotsky (1978), and Bruner (1966/2013) guided the constructivist and social constructivist theory upon which this action research was grounded. News articles and blogs provided secondary sources for contemporary evidence regarding the flipped classroom model and other active learning strategies (Hirsch, 2014; McMahon & Pospisil, 2005; Roshan & Roshan, 2012).

Methodologies

Six twelfth-grade female calculus students at EHS participated in this study. This school, which serves a population of more than 2,100 students in grades nine through twelve, is located in a fast-growing rural district located in the piedmont region of South Carolina. The teacher-researcher chose the flipped classroom model to implement and investigate in an attempt to improve teaching practices, introduce student-centered methods, and use active learning to encourage female students in their advanced mathematics studies. The flipped classroom model has peer-to-peer collaboration, active learning, and teacher-to-student interaction as its distinguishing features. The teacher-researcher designed an action research cycle to investigate female students' perceptions of the flipped classroom model applied to a calculus unit on limits. Brame (2013) described the flipped classroom model:

> 'Flipping the classroom' means that students gain first exposure to new material outside of class, usually via reading or lecture videos, and then use class time to do the harder work of assimilating that knowledge, perhaps through problem-solving, discussion, or debates. This model contrasts from the traditional model in which 'first exposure' occurs via lecture in class, with students assimilating knowledge through homework; thus, the term 'flipped classroom.' (p. 1)

During the limits unit, the teacher-researcher gathered data and sought feedback from the participants using classroom observations recorded as field notes and a mid-unit questionnaire. Then, to give a greater voice to the females who experienced the flipped classroom phenomenon, the teacher-researcher conducted a post-unit focus group. The qualitative data were thematically coded using NVivo software to determine patterns and

common phrases throughout the text. Means from the five-point Likert scale questionnaire provided quantitative information with which to polyangulate the themes that emerged from the qualitative data (Mertler, 2014). Study findings indicated that the flipped model provided: ways to increase differentiation of instruction; strategies to improve peer-to-peer collaboration and student-to-teacher interaction; methods to increase student responsibility in learning; and ways to vary student engagement with content material. The female students' perceptions of the flipped classroom model evolved throughout the study from first preferring a traditional teacher-led, in-class lecture, to later enjoying the student-centered classroom activities afforded by the flipped classroom structure. The teacher-researcher member-checked study results with student participants, and shared findings with both student participants and other advanced mathematics teachers at EHS. Finally, the teacher-researcher developed an action plan in collaboration with her colleagues for incorporating modified flipped classroom models in calculus classrooms at EHS for the 2018-2019 school year.

Conclusion to Chapter 2

The research reviewed in this chapter indicated mixed results about students' perceptions of the flipped classroom model, but researchers agreed that the flipped structure increases the active learning culture for classrooms. The flipped strategies were used in this study to create student-centered, active-learning experiences for female students, who have typically been underrepresented in advanced mathematics courses, to help them co-construct their mathematical knowledge (U.S. Department of Education, 2012). The literature indicates that the flipped classroom model can increase the active learning methods in a classroom and improve student-to-teacher and peer-to-peer

collaboration. Chapter 3 will detail the methodology employed for this action research study. Chapter 4 will report the data collected, share the results, and contextualize the study findings. Chapter 5 outlines the action plan for effecting positive educational change using the information gleaned from this action research study.

Chapter 3: Methodology

Introduction to Chapter 3

This chapter first provides an overview of previous studies found in existing literature on the flipped classroom model, and then details the methodological design used to answer the action research question regarding female students' attitudes concerning the flipped classroom model in an advanced calculus classroom. In a flipped classroom model, the traditional, public school, classroom and homework paradigm is shifted or flipped to a model where students learn their prescribed curricular content outside of the four walls of the classroom and use their allotted class time at school for active collaborative practice and application and for increased interaction with teachers. This action research study examined female students' reactions to the phenomenon of the flipped classroom model in a high school calculus course.

Problem of Practice

Before implementing this study, the teacher-researcher relied on traditional teacher-led classroom strategies in her AP calculus course. This study resulted from inquiry into student-centered strategies grounded in constructivist and social constructivist theory that might enable female students to actively participate in the collaborative acquisition and negotiation of mathematical knowledge. Female students at this developmental stage value social interaction. The flipped classroom model was implemented to foster student-teacher and peer-to-peer relationships by encouraging collaborative partner and group work (Boaler, 2002; Brown et al., 2017). Qualitative

research methods were used to investigate the perceptions of the female students regarding the phenomenon of the flipped classroom model.

Action Research Question

In order to create a student-centered environment informed by constructivist and social constructivist ideals and using active learning strategies for underrepresented female students in advanced mathematics, the teacher-researcher asked the following research question: What are female calculus students' perceptions of the flipped classroom model in AP calculus?

Statement of Purpose

The goal of this action research cycle was to investigate the flipped classroom model as a strategy for improving the teacher-researcher's practices and moving toward student-centered methods that can provide female students with better access to and understanding of mathematics by increasing their active learning in the calculus classroom. A secondary purpose was to investigate the student-participants' opinions of a teaching paradigm different from their traditional teacher-centered, lecture-format mathematics class.

Action Research Paradigm

Educators engage in reflection on their practices and examination of effective teaching methods with the intention of continually improving their skills and their profession. This natural cycle is part of a formal process known as action research. The goal of action research is to improve practices in a particular focus area (Mertler, 2014; Mills, 2014). The profession of teaching inherently lends itself to action research, as teachers evaluate their efforts in the classroom, seek alternative theory or methods that

will inform and improve their practices, study the consequences of new approaches, then reflect again on their effectiveness and begin the cycle again. Ferrance (2000) defines action research as a "disciplined inquiry done by a teacher with the intent that the research will inform and change his or her practices in the future" (p. 1). Along with intent of improvement, consideration of ethical issues is an essential component to any research setting as well. Dana and Yendol-Hoppey (2014) explained:

> Engagement in teacher inquiry as a form of professional development simply makes the normal, everyday work of teaching less happenstance and more visible, heightening the opportunity for teachers to improve learning conditions in their classrooms on a regular basis. When inquiry is approached in this way, choosing *not* to engage in the process can almost be viewed as *un*ethical (p. 149).

Once a focus has been chosen, action research uses a cycle of stages: a stage of studying and planning, a stage of acting, a stage of data collection and analysis, and a stage of reflection and adjustment; the cycles continue in this fashion. In this case, the inquiry examined female students' perceptions regarding the phenomenon of the flipped classroom model in AP calculus. The teaching strategy, which is operationally defined as the flipped classroom model, was implemented, then female opinions about the teaching method were gathered and described. Due to the fact that the participants in the action research study are assigned to the course section depending on their schedule and not by randomization, the teacher-researcher chose a phenomenological qualitative design (Mertler, 2014). Qualitative action research methods modelled after Strohmyer (2016), Lage, Platt, and Treglia (2000), and Johnson (2013) were used to examine rural, female, high-school students' perceptions of the flipped classroom model in AP Calculus.

Classroom observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus group were used to collect data to answer the research question about students' perceptions. Qualitative methods were more appropriate for giving voice to the story of these female students regarding the phenomenon of the flipped classroom model. While a quantitative study could be helpful in determining learning gains or achievement levels, the field notes, questionnaires, and focus group discussion provided the type of qualitative data needed to determine the perceptions and attitudes of the student-participants. Part of the information in the questionnaire was quantifiable using a five-point Likert scale, producing numerical data that served to polyangulate the observational data, the open-ended questionnaire data, and the focus group data (Mertler, 2014).

Researcher

The teacher-researcher maintained a dual position throughout this action research cycle, functioning both as an inside, invested member of the learning community and as an outside researcher responsible for preparing, collecting, analyzing and interpreting data to facilitate change. The insider role provided access to the participants in the shared experience that an outside researcher may not have been given. Dwyer & Buckle (2009) argued that "membership [in the group] automatically provides a level of trust and openness in your participants that would likely not have been present otherwise" (p. 58). However, the researcher's membership in the community under study also creates the potential for influence in relating to the student-participants.

Cognizant of the position of a teacher-researcher, in which there is direct involvement in the inquiry research, teacher bias was an additional ethical consideration. While there was no preconceived notion that the female students would hold favorable

attitudes regarding the flipped classroom model, the teacher-researcher had to resist adding any personal opinions to the study during the process of planning, executing, and interpreting to achieve data that could be properly used to address the problem of practice. According to Takacs (2003):

> Few things are more difficult than to see outside the bounds of your own perspective – to be able to identify assumptions that you take as universal truths but which, instead, have been crafted by your own unique identity and experiences in the world. (p. 27)

It is possible that student participants provided biased results with the hopes of pleasing their teacher, if they believed the teacher-researcher wanted them to think favorably of the flipped classroom strategy. Therefore, the teacher-researcher made all possible efforts to avoid influencing participant feedback throughout the action research process. The teacher-researcher often reminded students that the implementation of the flipped model was for exploration purposes, with the goal of determining whether the strategy would better serve their collective learning needs.

The teacher-researcher gained consent from the participants' parents and from the participants themselves, via letters distributed on the first day of class describing the action research and the data that would be collected. Data were collected in the forms of researcher observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus group discussion. The data were analyzed and the results were shared with the participants and with colleagues of the teacher-researcher. The principles of honesty and transparency were upheld in all aspects of the research process, from informing and gaining permission from the school district personnel, parents, and participants to the

final analysis and reporting of the data collected (Mertler, 2014). Armed with actual data concerning the female students' experiences with the flipped methodology, the teacher-researcher was able to reflect on the flipped approach with her students and use the data to assist in future planning to become a more effective teacher.

For this study, the teacher-researcher modelled the data collection methods after other studies to prevent bias in the questionnaire, and audio recorded the focus group in order to ensure authentic quotes of the participants. The teacher-researcher used the qualitative analytic software NVivo to search fields notes, questionnaire responses and focus group input for patterns and common phrasing that pointed to themes based on the data. In the position of teacher for the flipped calculus unit, the teacher-researcher had access to and interactions with the participants during class time that provided data for observational and field notes. The teacher-researcher also served as mediator for the focus group, gaining a level of interaction that provided a collaborative reflection on the intervention of the flipped classroom model. The teacher-researcher explained the research goal of improving teaching practices and creating student-centered experiences for the female participants, and informed students that their honest responses were requested regarding the phenomenon of the flipped classroom model, whether positive or negative. Participants were initially reluctant to open up about the negative aspects of their experiences, but as the conversation continued and as the level of comfort and trust grew, the participants shared their thoughts and suggestions more freely. The teacher-researcher's position as an insider – in this case, as a member of the learning community – provided a safe environment in which the student-participants could reflect on their experiences in collaboration with one another and with the teacher.

Participants

Since this action research study involved human subjects, the first ethical consideration involved securing permission from the principal at the school in which the study was conducted, as well as obtaining an exemption from the University of South Carolina's Institutional Review Board. The board approved the study of the proposed action research question, approved the action research plan, and deemed the results as providing beneficial information (see Appendix A). Upon obtaining authorization from the district and from the school, the teacher-researcher obtained consent from the parents/guardians of the subjects and from the subjects themselves (see Appendix B and Appendix C). Through the distribution of a letter/permission form, the teacher-researcher informed parents of the purpose of the action research, outlined the design elements of the study, and explained that "participation in the study is voluntary and can be terminated at any time without penalty" (Dana & Yendol-Hoppey, 2014; Mertler, 2014). To assist with establishing trust, the consent letter included a guarantee of confidentiality and anonymity, and offered to provide results from the study to the participants (see Appendix C). The teacher-researcher assured the student-participants that data collection methods in this action research study were designed for the mutual benefit of all parties, with the goal of creating a more student-centered environment that would promote underrepresented females in advanced mathematics. This assurance aided in the establishment of the reciprocal relationship whereby the student-participants better understood their roles as participants and beneficiaries of the action research cycle.

The research examined student perceptions of the flipped classroom model using observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus

group discussion. In order to maintain confidentiality and adhere to the protection of student information under the Family Educational Rights and Privacy Act, pseudonyms were used when reporting specific data (Dana & Yendol-Hoppey, 2014). Aggregate data were also included when sharing the responses to the questionnaire (Mertler, 2014).

The primary purpose of this action research was to improve the teacher-researcher's classroom practices – specifically to provide a student-centered environment promoting active learning strategies for underrepresented female students in advanced mathematics. Therefore, the research focused on determining female students' attitudes towards the flipped classroom model in an AP calculus course, following Mertler's (2014) principle of beneficence, which explains that studies should be performed with intention of promoting a group of people. Though entering the research process with no preconceived notion as to the attitudes of female learners regarding the flipped classroom model in secondary calculus, the teacher-researcher chose this methodology with the benevolent intention of improving teaching practices and effecting positive educational change.

Flipped classes include a component that requires students to take on responsibility for a portion of the learning outside of the classroom in order to engage in activities in the classroom. In a one-to-one initiative, the Eagle school district provided the necessary technology for students to access videos outside of the classroom via an Apple MacBook Air. Because Internet availability was a necessary component of the flipped classroom model, the teacher-researcher confirmed that all students in the AP calculus class had access to the Internet during the school day and in their homes. Students could have chosen to watch the videos during the school day, download the

videos during the school day to watch outside of the school day, or access the videos outside of the school setting altogether.

The specific participants were determined by the enrollment in an AP calculus class taught by the teacher-researcher. The class met from 8:25 a.m. to 9:55 a.m. each day throughout the 2017-2018 school year. The six female students enrolled in the class served as the sample for this action research cycle. All six female students were Caucasian, lower- to middle-class, high-achieving students. They were all in 12th grade and taking the AP calculus course at EHS.

Amy (pseudonym) was a high-achieving, conscientious young woman also enrolled in AP statistics. She was active in two service clubs at school, and planned to major in exercise science in college. Wendy (pseudonym) was a quiet, shy female who did not speak out in the traditional teacher-led classroom setting, but was comfortable working in pairs or small groups with other female students. She expressed aspirations of majoring in mechanical engineering in college. Abby (pseudonym) was typically absent between one and three days of school each week as a result of having trouble getting up in the morning to get to class on time. She was a hard worker who knew where to find her missed work online and took her time to try and make sense of the lessons she missed before returning to class. She planned to major in biology in college. Kerrie (pseudonym) was a young woman who enjoyed the challenges of mathematics, but struggled to understand the material the first time it was presented and had difficulty retaining pre-requisite knowledge from prior courses. She took pride in her leadership role in the Air Force Junior Reserve Officer Training Corps and in her community service efforts. Due to the effects of a brain tumor, she needed lesson notes to be provided to her

so that she could keep pace with her classmates in the traditional, teacher-led, lecture-based setting, but the flipped model gave her opportunities to pause and rewind the lessons as needed. She expressed an interest in the study of psychology in college. Becky (pseudonym) was an expressive young woman who was comfortable speaking out in any classroom setting. She was an officer in one of the service clubs at the high school and planned to study anthropology in college. Maggie (pseudonym) was an inquisitive and conscientious mathematics student who asked many clarifying questions in a one-on-one setting, but did not like to speak out in a whole-class setting. She was school spirited and participated in volleyball and National Honor Society. She identified nursing as her post-secondary interest.

Data collected from the six female participants examined their experiences with the phenomenon of the flipped classroom model in AP calculus. Due to the small sample size, the teacher-researcher was able to interact with each participant daily to compile observations and field notes. The small sample size also allowed the teacher-researcher to invite all six participants to participate in the focus group at the conclusion of the calculus unit. While all six participants agreed to participate, Abby missed the meeting because of a tutoring obligation that day. Due to her frequent class absences, Abby expressed appreciation for the video lessons and indicated that she often looked up lessons online when she was absent from class in any subject.

Setting

Since the sample was a small population of participants from a very specific locale and since the study focused on a course in one level of mathematics, study findings may not be generalizable to other populations or settings. Traditional research is designed

to provide generalizable results based on validity and reliability, but this action research study focused on a specific context with the purposes of enacting change and improving the practice of the teacher-researcher in that particular setting, without concern of generalizability or future replication (Mertler, 2014). This particular study examined the opinions of the female students concerning the flipped classroom model in AP calculus at EHS. As action research serves to address a particular and local problem of practice, it does not meet the experimental research requirement for generalizability (Walliman, 2005). The quality of action research is determined by the procedures used to safeguard against bias and the usefulness of the findings for the proposed audience (Mertler, 2014). Though there was no reason for replicating the study to verify its reliability, the district and school setting in which the action research was conducted is described here for the intention of explaining the context for this particular study.

This action research took place in the teacher-researcher's calculus course at EHS during the fall semester of 2017. The high school is located in a fast-growing, working-class community in the upstate piedmont region of South Carolina. The community population is divided between more affluent residents and lower-income, long-time residents. In the more affluent portion of the population are approximately 9,000 retirees and business executives who have moved into the area from other parts of the country, have a median income of $74,300, and 50.9% of whom have bachelor's degrees or higher. Conversely, the other major part of the community population is composed of long-standing local families tied to the area's agricultural and textile past. This population is approximately 5,300 in number, with a median income of $24,619, and just 15.8% of whom have bachelor's degrees or higher. The school district is renowned for its

outstanding school system and student performance on standardized assessments. The district includes six elementary schools, two middle schools, and one high school. This district also has one alternative school system for grades five through twelve and one applied technology center for grades nine through twelve. The high school has an enrollment of more than 2,100 students, a student population that has more than doubled over the past 10 years. Approximately 100 of the students at EHS enroll in either the honors or AP level of calculus each year. According to the high school registrar, 30.4% of the high school students are provided free/reduced lunch and the ethnicity for the high school is as follows: 81.0% European American, 10.1% African American, 3.3% Hispanic, 1.7% Asian, .2% Hawaiian-Pacific Islander, and 3.7% other.

The majority of the classes at EHS are scheduled in 90-minute blocks that meet every day through the 90-day semester, with some variations to accommodate for scheduling and other issues. The action research study was implemented in a class that met daily from 8:25 a.m. to 9:55 a.m. throughout the 2017-2018 school year. The prerequisite for taking the AP calculus course at EHS was an average score of at least 80 in the honors-level trigonometry/pre-calculus course, a standard that typically restricted enrollment of this course to students in the 11^{th} and 12^{th} grades. When surveyed in the fall of 2017, all calculus student-participants confirmed that they had Internet access at home. Students also had computer use as the result of a 2014 one-to-one technology initiative at the school through which each student was issued an Apple MacBook Air to use for educational purposes during the school year. This equity of access to technology served to be useful for this action research study.

Instrumentation and Materials

The teacher-researcher maintained a daily record of informal observations, field notes, commentary, and reflections about the experiences of students and the teacher with the mathematical content in the flipped classroom model (Clark, 2013; Strayer, 2007). The form used to record the observations as field notes was used to document the happenings in the classroom as the students participated in the collaborative learning activities (see Appendix D). Dana and Yendol-Hoppey (2014) suggested that "surveys can give students a space to share their thoughts and opinions about a teaching technique or strategy, a unit, or their knowledge about particular subject matter" (p. 114). Therefore, halfway through the unit on limits, the teacher-researcher administered a 20-item questionnaire modified from similar studies to gain feedback on the flipped classroom methodology (Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Ziegelmeier & Topaz, 2015). The questionnaire contained 17 questions with responses based on a five-point Likert scale, and three open-response questions (see Appendix E). After the unit on limits was complete, the teacher-researcher held a focus group discussion with five of the six female student-participants (Clark, 2013; McGivney-Burelle & Xue, 2013; Strayer, 2007; Strohmyer, 2016). The focus group questions were used to guide the discussion and gain insight into the student-participants' opinions of the flipped classroom model (see Appendix F). The focus group was audio recorded and later transcribed along with the teacher observations and the three open-ended questions from the questionnaire, with all data entered into the NVivo qualitative analysis software to search for repetition of phrases and patterns in the responses.

Data Collection

With the purpose of improving pedagogical practices, the teacher-researcher designed an action research cycle to explore the perceptions of female students about the flipped classroom model in a calculus unit on limits. The calculus unit on limits was chosen because the objectives have an intuitive quality and there are many online resources and activities available to enrich this unit. The specific goals for this unit included finding one-sided and general limits, as well as those involving infinity, and finding limits algebraically, graphically, and analytically. The structure of the flipped model for this action research study was one where students were introduced to new calculus content at home via instructional videos and used in-class time for collaborative practice. The female students were assigned YouTube videos and website demonstrations from which they gained initial exposure to the content on limits outside of class time. During class time, the students solved limit problems, participated in explorations and activities, and worked collaboratively with partners or small groups and with teacher assistance to construct graphical representations of open-ended questions using limit properties. Class time was also used for further explanations of content and for opportunities to strengthen the students' understanding of limits. Upon completion of the limits unit, the teacher-researcher conducted a focus group discussion with five of the six female student-participants, audio recording the interactions for subsequent transcription and entry along with the other qualitative data into the NVivo software for thematic coding. The data were analyzed and reflected on with the student-participants, then shared with other mathematics colleagues at the high school and used to develop an

action plan for implementing variations of the flipped classroom model with other calculus courses in the 2018-2019 school year.

Data Analysis and Reflection

Since the focus of this action research study was to explore a teaching methodology that creates a more active, student-centered classroom environment for female students in advanced mathematics, qualitative data were collected to determine the perceptions of the female students regarding the flipped classroom model. Statements from the field notes, answers to the open-ended questionnaire, and focus group input were transcribed and analyzed by the teacher-researcher to identify trends in the phrasing. Next, the transcripts were entered into the NVivo software program to detect common themes. The following themes emerged during the qualitative data analysis:

1. The flipped model allowed for increased differentiation of instruction.
2. The flipped model provided a strategy for improving peer-to-peer collaboration and student-to-teacher interaction.
3. The flipped model is a method for increasing student responsibility in learning.
4. The flipped model allowed for variations in student engagement with content material.

In addition, the quantitative data gathered from the questionnaire was analyzed using a five-point Likert scale and used to poly-angulate the qualitative data and support the significance of the identified themes for this group participants. On the mid-unit questionnaire, the female participants reported their preference for teacher-led lecture as an instructional strategy, but in the post-unit focus group, they indicated their favorable

opinion of the collaborative classroom activities and of the flipped model and suggested that the instructional videos be recorded by the teacher.

During the reflection phase of this action research, the teacher-researcher and student-participants determined that the data accurately represented the phenomenon experienced in the flipped classroom model and was sufficient to address the problem of practice. Also, as Mertler (2014) suggested, the findings were shared with the participants, school administrators and mathematics colleagues. When sharing the data, pseudonyms were used to identify student participants. The findings from the analysis assisted in the reflection on the female students' perceptions of the flipped classroom model in mathematics. The results were used to formulate an action plan for future action research cycles and for additional exploration of flipped methodology in calculus classrooms at EHS in the 2018-2019 school year.

Conclusion to Chapter 3

The impetus for this action research was to investigate the flipped classroom model as a strategy for improving the teacher-researcher's commitment towards student-centered pedagogy by increasing female students' active learning strategies in the calculus classroom. The underlying purpose of this action research is to explore female students' opinions of the flipped classroom model in advanced mathematics. Action research methods provide a structure whereby educators can evolve in a continuous cycle. The action research question driving this study was: What are female calculus students' perceptions of the flipped classroom model? With the purpose of the betterment of teaching practices for the benefit of increased active learning strategies for female students, the flipped classroom methods were researched as well as the theoretical

underpinnings and historical context of the flipped classroom structure and reported in Chapter 2. Using this information and prior studies as a guide, a phenomenological qualitative research design plan, for which the methodology is detailed in this chapter, was established to allow the collection of data to try to answer the research question. Chapter 4 details the data that was collected and analyzed for prevalent themes. Those findings were shared with the student-participants and with colleagues of the teacher-researcher. Finally, Chapter 5 explains how the findings were reflected on in collaboration with the student-participants and EHS mathematics teachers to develop an action plan for improving the culture in advanced mathematics classrooms at the high school, addressing the problem of practice, and impacting positive educational change.

Chapter 4: Findings and Implications

Introduction to Chapter 4

This action research inquiry investigated students' perceptions of the flipped classroom model in a calculus classroom. The teacher-researcher previously relied on more teacher-centered traditional classroom pedagogy to teach AP Calculus and sought to reform classroom practices towards student-centered methods that are grounded in constructivist and social constructivist principles and that have the potential to increase active learning strategies for underrepresented female students in advanced mathematics. The flipped classroom model moves direct instruction out of the classroom, leaving class time for more collaborative and active assignments. The design of the flipped model was informed by Dewey's (1938) focus on education being student-centered and Vygotsky's (1978) contention that learning occurs through social-interaction. As the literature reviewed indicated, active learning strategies provide opportunities for students to participate collaboratively in the co-creation of their understanding of mathematics, and the classroom activities allow students to learn together by increasing their interaction. The teacher-researcher implemented a flipped classroom model with six female students for the calculus unit on limits and collected data about the students' perceptions through informal observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus group discussion. In Chapter 4, the researcher presents the data, findings and implications for the present action research study, designed to describe the perceptions of

the six female students regarding a four-week calculus unit on limits in a flipped model class at EHS in South Carolina.

Problem of Practice

To create a more student-centered mathematics environment at EHS, the teacher-researcher designed a flipped classroom model to investigate the perceptions of female AP calculus students regarding the shift to that classroom model. The flipped classroom model for the present study involved using YouTube instructional videos to teach calculus content outside of class, permitting female student-participants to be interactive with the material, with their classmates, and with the teacher-researcher during class time. Student-centered teaching methods are recommended as a strategy to support underrepresented females in courses in the field of mathematics (NCTM, 2009; Wiest, 2014; Boaler, 2002). Studies also suggested that an inverted or flipped classroom model, where content is delivered outside of the classroom, left more class time for student-centered activities, improved teacher-student interaction, and increased achievement (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). Therefore, the teacher-researcher aimed to seek alternative, student-centered methodologies by using the flipped classroom model to enable the six study participants to access mathematics content in a way that is different from the traditional, teacher-led, lecture-based format typically used at EHS. The teacher-researcher used the flipped classroom model with the calculus unit on limits and gained feedback from the six female students regarding this teaching strategy in order to improve classroom practices and

share knowledge the school's other mathematics teachers in an effort to improve education culture for female students.

Action Research Question

In order to create a student-centered environment, informed by constructivist and social constructivist principles, for underrepresented female students in advanced mathematics, the teacher-researcher asked the following research question: What are female calculus students' perceptions of the flipped classroom model?

Purpose Statement

The teacher-researcher designed this action research study to reform traditional, teacher-centered pedagogy to an active, student-centered pedagogy for the underrepresented female students in advanced mathematics courses at EHS. A flipped classroom model was developed for investigation as a teaching strategy for improving the teacher-researcher's practices using methods supported by constructivist and social constructivist ideals and providing female students better access to and understanding of mathematics concepts through increasing their active learning strategies in the calculus classroom.

Research Overview

This qualitative phenomenological action research study was conducted over a four-week period in the fall semester of 2017 at EHS, a public high school located in the upstate region of South Carolina. The population for the study consisted of six female, 12^{th}-grade students in AP calculus, all of whom participated in extracurricular activities such as service clubs, student council, sports, or Air Force Junior Reserve Officer Training Corps. Typically, mathematics classrooms at EHS use traditional, teacher-led,

lecture-based pedagogy. To investigate a student-centered alternative pedagogy, the teacher-researcher designed a flipped classroom model for use with her class during the calculus unit on limits. The flipped classroom is a pedagogical strategy in which the teacher serves as facilitator while students co-construct their learning socially and collaboratively with one another based on their personal experiences (Bergmann & Sams, 2012). The flipped classroom model used for this action research involved the introduction of new content outside of the classroom setting via online YouTube instructional videos that students viewed independently at home or throughout the school day outside of their scheduled calculus class. The videos were from a variety of presenters (see Appendix G). The presentation of content via the instructional videos provided student-participants with the opportunity to pause the video and repeat sections of the instruction as necessary, an option not afforded to students in a teacher-led, lecture-based classroom setting. Student-participants were instructed to take notes of the examples presented in the video lessons and record clarifying questions in their notes to bring to class. During class time, the students who considered themselves prepared to apply their knowledge worked in small groups or partners on a variety of tasks, including practice worksheets, the creation of graphs with given limit descriptions, and explorations using a card matching activity. Students who needed clarification with the material were able to interact with a classmate or ask the teacher for additional explanation as they made meaning of the material concerning the properties of and strategies for solving limits.

The teacher-researcher collected data using informal observations recorded as field notes, a mid-unit questionnaire, and a post-unit focus group. The thematic coding of

the data revealed that the flipped classroom model allowed for ways to increase the differentiation of instruction, provided strategies to improve peer-to-peer collaboration and student-to-teacher interaction, offered methods to increase student responsibility in their learning, and afforded ways to vary student engagement with content material. These themes will be further explained in this chapter. Regarding the female students' perceptions of the flipped classroom, the data provided mixed results. On the mid-unit questionnaire, the students indicated their preference for a teacher-led lecture pedagogy, but in the post-unit focus group discussion, the participants explained that their initial apprehension toward the flipped model was caused by an unfamiliarity with the strategy and reported that by the end of the four-week unit they had come to regard the flipped classroom more favorably.

Chapter 4 contains a summary of the data collected, the findings from this study, a reflection on and interpretation of the results of the data with the student-participants as they relate to the research question, and a report of the findings shared with other mathematics teachers in order to structure more student-centered mathematics classrooms at EHS that are more beneficial for female students.

Data Collection Strategy

Data collection focused on answering the research question concerning the perceptions of six female students regarding the flipped classroom model implemented for an AP calculus class at EHS in South Carolina. In this qualitative observational research study, the female student-participants were enrolled in an AP calculus course taught by the teacher-researcher (Mertler, 2014). This class met daily for 90 minutes from 8:25 a.m. to 9:55 a.m. The teacher-researcher selected the flipped classroom model for

investigation because of its student-centered approach that encourages female students to be more active and cooperative in their learning, thereby providing increased access to higher-level mathematics curriculum (NCTM, 2009). The teacher-researcher designed a flipped classroom model for a calculus unit on limits using features outlined by Bergmann and Sams (2012), Chen et al., (2016), Clark (2013), and Johnson (2013), aiming to create a more collaborative in-class environment in which students could co-construct their mathematics knowledge together, with their teacher serving as a facilitator. During the instructional unit on limits, the female students were assigned YouTube instructional videos to watch as homework, with the videos providing introduction to new calculus content prior to the class and thereby freeing class time for collaborative practice and interaction with the teacher. The students could choose among multiple instructional videos, and had the opportunity to access additional online, video-based materials depending on their desire for a variety of presentations, on their preferences among available presenters, and on their need for clarification (see Appendix G). Viewing the instructional video prior to class allowed the students the opportunity to participate during class time in collaborative partner or group classwork assignments and to interact with the teacher for one-on-one assistance. Teacher-researcher observations recorded as field notes, responses to a mid-unit questionnaire, and input from a post-unit focus group provided qualitative data that gave voice to the six female participants and their experiences with the phenomenon of the flipped classroom model. The narrative data displayed themes that are further described in this chapter.

Participants

The six female participants were in 12th grade and taking AP Calculus at EHS. Amy (pseudonym) was a high-achieving, conscientious young woman also enrolled in AP statistics. Wendy (pseudonym) was a quiet female who rarely spoke out in the traditional teacher-led classroom setting, but was worked well in pairs or small groups with other female students. Abby (pseudonym) was frequently absent, but took it upon herself to acquire her missed work and completed it prior to her returning to class. Kerrie (pseudonym) struggled with the content in advanced mathematics, but appreciated the challenge that calculus posed. Kerrie had slow motor skills as a result of a brain tumor, so in the traditional, teacher-led setting, she was provided notes in class so that she could focus on attainment of the content rather than writing the steps and examples that were covered in a lecture. However, in the flipped model Kerrie was able to pause, rewind, and rewatch the lessons as needed to gain a greater understanding. Becky (pseudonym) was a confident young woman who was comfortable sharing her thoughts and questions in any setting. Maggie (pseudonym) was a diligent mathematics student, though she was not confident in her abilities and needed encouragement and support often. Also, Maggie asked many clarifying questions in a one-on-one setting, but did not like to speak out in a whole-class setting. Further details about each participant is included in Chapter 3.

For small group work in the unit on limits, the teacher-researcher divided the students into two groups of three based on their previous social interactions and ability levels. Palincsar (1998) reported heterogeneous grouping based on varied comprehension levels attain understanding quicker than groups of homogeneous-ability students. Each group consisted of one girl who had achieved an A on the previous test, one who scored a

B+, and one with a test score of B-. Abby, Becky, and Maggie were placed in Group 1, and Amy, Kerrie, and Wendy made up Group 2. The purpose of the action research was explained in a consent letter distributed at the beginning of the school year (see Appendix C). The participants expressed excitement about the prospect of studying mathematics in an environment that would allow them to be more active participants and to collaborate and interact with one another as they made meaning of the mathematics concepts together. These students indicated trust in the teacher-researcher's assurances that the investigation of their perceptions regarding the flipped classroom model was designed to explore classroom environments that might better suit their learning needs.

Observations/Field Notes

During the instructional period, the teacher-researcher maintained a checklist of behaviors for the student participants (see Appendix D), recording whether the students watched videos prior to class, took notes, copied examples, and wrote clarifying questions from the videos as instructed, and whether or not they participated in the collaborative practice in class. As the research unfolded, the teacher-researcher discovered the need to better track the phenomenon of the flipped classroom model during class time, and therefore used previously created checklists to record the happenings and mathematical discussions in the classroom, as well as to note initial interpretations of student perceptions as field notes for one data set in this study.

The collection of data in the form of observational field notes indicated that most of the students gained sufficient knowledge from watching the instructional video lessons to actively participate in the class assignments. Field notes showed that students in Group 1 collectively claimed that, while they had confidence in working through the one-sided

and general limits problems graphically, they did not have an understanding of why they were learning this topic. Kerrie, in Group 2, said that the YouTube video with Nancy as the presenter was "easier to understand because she had no class of students behind her."

As the unit on limits progressed, the field notes included the observation that the students were more collaborative in the flipped classroom setting and engaged in critical mathematical discourse with one another. Students also grew less dependent on the teacher for their questions, turning instead to their notes, to another classmate, or to online resources. For instance, when evaluation of a limit by substitution resulted in an indeterminate form that required factoring a sum of cubes, the students researched this technique online instead of relying on their teacher as the only source of knowledge. Observations showed an increase in the levels of student independence and student responsibility as the familiarity with the flipped classroom model increased.

Questionnaire

Mid-way through the unit on limits, the students completed a 20-item questionnaire to provide feedback about what they thought was working in the initial pedagogical design and what modifications they wanted to see. The teacher-researcher developed the questionnaire by modifying a similar survey used in Johnson's (2013) study (see Appendix E). The instrument consisted of 17 questions that used a five-point Likert scale for responses, and three open-ended questions regarding the advantages and disadvantages of the flipped classroom model. The mean and standard deviations of the student responses to the questionnaire provided the quantitative data shown in Table 4.1 below.

Table 4.1.
Results for the Five-Point, Likert-Scale Questionnaire Administered September 8, 2017

Question	Mean	SD
Communication	3.50	.837
Engaging class time	2.67	1.211
Liked videos	3.17	.753
Less time on homework	3.33	1.506
Participated in videos	4.50	.548
Preferred traditional model	3.83	.983
Less practice	2.67	.816
Motivation	2.67	.816
Not recommend	2.67	.816
Improved learning	2.33	1.367
Continue flipped	3.00	1.265
Access to teacher	4.00	.632
Independent learner	3.33	.816
Responsibility	4.50	.548
Engaged with content	2.50	1.378
Collaboration	3.67	1.367
Increased teacher interaction	3.50	1.049

In the open-ended portion of the questionnaire, the students identified the advantages of the flipped classroom model as being: (a) increased interaction with the teacher, (b) more responsibility on the part of the learner, (c) less time spent on homework, (d) the ability to pause and rewind the lesson as they watched the instructional videos, (e) and the continual availability of the instructional videos for review. The students listed the disadvantages of the model as: (a) a lack of motivation to watch the presenters in the instructional videos, (b) the impersonal nature of the

instructional videos, and (c) the inability to have immediate access to the teacher to answer their questions as they watched the introduction to new content on the instructional videos. Four of the six female participants recommended that class begin with a group review of the instructional videos to clarify their understanding prior to their collaborative classroom assignments.

Focus Group

Since the population size for this study was small, the teacher-researcher could invite all six of the females to participate in the focus group. All of the students accepted the invitation, but Abby was unable to attend as a result of a science tutoring obligation that occurred at the same time as the focus group. Due to the students' after-school commitments, the 50-minute focus group conversation began in the class period and finished during the school's "flex time" set aside twice a week for students to use the media center, visit the student union, or meet with their teachers for assistance or to complete make-up work. The flex time immediately followed the participants' calculus class time. The students had already participated in the flipped unit on limits prior to the focus group session. The students seemed initially hesitant about speaking directly to their instructor in the focus group setting regarding teaching methods. However, the teacher-researcher assured the participants that the purpose of the focus group was to gather additional data concerning their experiences with and perceptions of the flipped classroom pedagogy, to determine their understanding of the concepts presented during the unit on limits, and to understand their learning styles and preferences in order to create a classroom environment that would best provide them with access to higher-level mathematics. The teacher-researcher also assured students that there were no pre-

conceived notions regarding their opinions of the flipped classroom. Once the conversation began, the students became more comfortable in the setting and grew increasingly relaxed and responsive to the focus group discussion prompt: "Describe your learning experience during the flipped class model." During the focus group conversation, the teacher-researcher reviewed the data collected from the checklists and observational field notes with the students, and reflected with them regarding the practices they saw as beneficial and the strategies they believed required further development or should be excluded from future lessons. The students' responses were audio-recorded during the focus group, then transcribed later that same day.

As a group, responses on the mid-unit questionnaire indicated that students were disengaged from the instructional video lessons and preferred traditional, teacher-led classroom structure. In the focus group setting, however, the students provided more detail on their perspectives. In the focus group, the students also responded supportively to the suggestions and ideas of one another. They explained that it was not the format of the instructional video that left them disengaged, but rather the presenters on the videos. Becky detailed her preference for a teacher-made video, stating "it would be easier to learn from the particular voice you trust and associate with that topic and at a pace you are familiar with." The other participants agreed with Becky's analysis of the presenters in the videos. Amy said, "I think it would be better if you [the teacher] made the videos," and Maggie said, "I think it would be better if you [the teacher] made the video and taught the lesson. I just did not like the girl in the video. She went too fast."

Becky and Wendy revealed another criticism of the flipped classroom model in the focus group discussion. Both indicated that they were less motivated to watch a video for homework than to complete a more traditional assignment. Becky said,

> I am more compelled to do [traditional homework]. Like, if I have a tangible worksheet, I'm probably going to make time, no matter what, because I know that I can physically turn it in. But if we just have a video to watch, it doesn't equate to the same level of importance to me, even though they probably are.

Wendy expressed similar sentiments, saying "At home or at work, I can work on an assignment while I watch TV or listen to music or multitask, but I can't watch a video and do other things."

The students verified the teacher-researcher's observations that the flipped classroom model increased peer-to-peer collaboration and discussion. Kerrie stated, "I liked working together during flipped and felt more connected to people in class," and Wendy said, "I liked working together, too and would like to do more [flipped] sometime, but maybe not a whole unit." The focus group input served to provide yet another source of data that could be polyangulated with observations and questionnaire data to gain a greater understanding of the instructional practices that provide better access to advanced mathematics for female students (Mertler, 2014).

Ongoing Analysis and Reflection

To facilitate change that would improve the student-centered classroom environment for female students that are traditionally underrepresented in higher-level mathematics, the teacher-researcher investigated the student-centered flipped classroom model. The teacher-researcher designed a flipped classroom model to provide class time

for active learning and increased interaction among students and between the teacher and students (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). As an insider and member of the study community, the researcher took steps to avoid bias, including maintaining checklists and observational field notes during the study of the unit on limits. Because some of the class time was devoted to interaction with the students, the teacher-researcher also used planning time immediately after the class time to record information on the checklist and add comments and reflections to her field notes. The recorded observations indicated an early theme that students became less dependent on their teacher as the only source for information about the mathematical content.

The teacher initially expected that students would watch the assigned instructional videos at home or another time prior to class, pause and rewind the videos as needed, write down questions that came up for clarification, come to class ready to get answers to their pre-written questions, and be ready to participate in their class assignments. However, during classroom observations and during conversations with students at the beginning of the unit, the teacher-researcher observed indicators that some students were not ready to participate in the group work during class after a single viewing of the content videos, and that others had not watched the assigned instructional videos at all. While initially surprised that these honors students did not complete the homework assignments of watching the instructional videos, the teacher-researcher returned to the goal of providing the best environment for these female students, realizing that if the flipped pedagogy was not conducive to their learning styles or their schedules, the

effectiveness of the strategy would need to be reconsidered and adjustments would need to be made. As a result of these early observations, the teacher-researcher redesigned the flipped classroom model to provide a designated area for some students to view the video lessons while the students who felt they were ready to practice and apply their knowledge could work together on the daily assignments. To provide increased motivation for watching the instructional videos outside of class, an element of accountability could be added to the flipped model by incorporating short assessments to be completed at the beginning of the class time together.

The mid-unit questionnaire offered student-participants the opportunity to provide input in their own words about the flipped model. It was through the mid-unit questionnaire data that students offered recommendations for improving the initial design of the flipped model. Five of the six students indicated that even when they had watched the videos and taken notes, they believed they would benefit from a more extensive review of the instructional video lessons at the beginning of each class. In response to this suggestion, I added a review to the beginning of the class for students who needed a group discussion and summary of the content that was covered in the videos. I observed that the students gained confidence in their ability to initiate and complete the in-class assignments after modifying the flipped model to include a review of the instructional videos. Responses to the mid-unit questionnaire also led to the initial identification of some recurring themes: (a) increased student responsibility, (b) increased peer-to-peer collaboration, (c) improved communication, (d) increased access to the teacher, (e) varying levels of engagement with the content, (f) a desire for class time devoted to review, and (g) varying opinions of the instructional videos. This list was later refined

with the student participants to note that the flipped classroom model provided ways to increase differentiation of instruction, provided strategies to improve peer-to-peer collaboration and student-to-teacher interaction, provided methods to increase student responsibility in learning, and provided ways to vary student engagement with content material.

Data collection also included a focus group with five of the six female participants. Due to the small population, I invited all of the six female students to participate in the focus group in order to gather the views of those students who had watched every video on time such as (Kerrie, Maggie, Amy, and Abby), and also to gather input from Becky, who had missed one of the viewing assignments, and from Wendy, who had missed watching several of the video homework assignments. As a part of my role as an outsider seeking to gain a deeper understanding of the female students' perceptions, I asked the students to describe their experience with the flipped classroom structure. They revealed that, in general, they preferred learning through direct, teacher-led instruction. As traditional teacher-led instruction is the primary teaching strategy employed in the mathematics department at EHS, the participants expressed a comfort level due to their familiarity with that pedagogy. With additional probing about what elements of the flipped classroom model they found favorable, they mentioned that they preferred the collaborative in-class activities they experienced for practice, exploration, and making meaning of the mathematical concepts associated with limits. After further investigation, they indicated that they were open to future experiences with the flipped model pedagogy with some suggestions for adjustment. This feedback suggested the female participants could benefit from a combination of teaching strategies depending on

the content or the tasks associated with the content. The students contributed to the early analysis of the data by verifying the major ideas previously identified from the teacher-researcher's observational field notes and from the mid-unit questionnaires, and reinforcing groupings of the ideas into themes.

Reflective Stance

Reflection is an essential piece of the iterative action research process (Mertler, 2014). Serving as an insider and member of the learning community being studied, the teacher-researcher, in conjunction with student-participants and colleagues, regularly reflected on the strategies chosen throughout this action research study in order to best address the creation of an environment that would enable these females to play a more active role in their mathematical learning by co-constructing their knowledge through social interaction with one another and with the teacher-researcher. This action research cycle began with a research question regarding the impact of the flipped classroom model on female student achievement, but as Mills (2014) explains, "once we start our journey of investigation, we have no way of knowing in advance where we will end up" (p. 4). The teacher-researcher concluded that achievement on teacher-made pretests and posttests would not provide the type of data that would address the purpose for this phase of action research inquiry, which was to investigate the flipped classroom model as a strategy for creating a more student-centered classroom environment for female students. Instead, a qualitative examination of student perceptions regarding the flipped classroom model emerged as a more appropriate method for addressing the problem of practice. The teacher-researcher, therefore, made the decision to alter the data collection method from a pretest/posttest quantitative design to a phenomenological, qualitative design that

included observations recorded as field notes, a questionnaire, and a focus group used to determine the female students' feelings concerning the student-centered flipped model design. A future cycle of action researcher could engage in the quantitative study of the effects of the flipped classroom model on achievement.

Reflection on the Checklists

The student-participants assisted in the development of a checklist of behaviors that were relevant to the daily operations in a flipped classroom. The necessary behaviors were: (a) to watch the assigned video lessons prior to class, (b) to take notes and copy examples from the videos, (c) to write questions for clarification to ask the teacher in class, and (d) to participate in the class practice or collaborative assignments (see Appendix D). This checklist was helpful in tracking the participation of the females during the study, but it become evident in the initial class meeting during the study of the flipped classroom model that more information would be necessary to gain a thorough description of what occurred in the classroom. Based on Yin's (2011) suggestion of observation as a data collection method suited to collecting information regarding participants' experiences, the teacher-researcher concluded that logging observational field notes and informal observations would provide a deeper understanding of the phenomenon of the flipped classroom with these particular students. Acting in the role of outsider/researcher to recording observations from student conversations provided insight into their understanding. However, it was sometimes necessary to act in the role of insider/teacher in order to facilitate the class, which prevented some observation recording during class time. For future cycles, video recording of class sessions would alleviate this difficulty and allow the teacher-researcher to transcribe the class

experiences at a later time so that he or she could focus only on the teaching role and on interactions with students during the class time.

Reflection on the Questionnaire

The questionnaire used mid-way through the unit on limits was designed to get feedback in order to assist with the evolution of the flipped model design for this study. There is debate about the inclusion of a neutral option in the design of a Likert scale (Johnson & Morgan, 2016). While a middle response can provide faulty information or convolute the data, there are situations where a middle option is required. Due to the nature of the questionnaire used in this study, the better option would have been to only use four choices instead of the five-choice design (see Appendix E). The neutral option of "neither agree or disagree" allowed the students the opportunity to avoid making a definitive choice about their preferences and feelings concerning the flipped classroom model.

Reflection on the Video Content

The teacher-researcher monitored the action research by leading informal conversations about the lessons with the student-participants each day, seeking feedback regarding the accessibility of the presentations, length of presentation, and quality of presenters in the videos the students chose to watch for the introduction of new content. The instructional videos were used to introduce the students to the calculus content on limits. Initially, the students indicated that even with several choices available for the lessons, they preferred the YouTube instructional videos by Nancy because she was easy to understand and her videos were shorter. The students expressed their dislike of the Khan Academy videos, saying that they could not see the presenter, but could only see a

screen where the mathematics was worked out. They indicated their preference for seeing the presenter's face. This input gave rise to another key question: What impact does the type of instructional videos used have on students' perceptions of the Flipped Classroom Model? This question can be explored during a future cycle in this action research process.

Reflection on the Focus Group

Students indicated a need for additional collaborative exercises in class. The first day, students completed an exploration into the meaning of a limit. One day, the students were assigned to their small groups to complete a card-matching activity in which graphs, verbal descriptions, and equations had to be matched in a set based on their traits involving limits. Also, the students participated with a partner to develop graphs based on a given set of limit characteristics. Another day, the students completed worksheets for practice with a partner or in their small group. During the focus group, the participants requested more collaborative and hands-on class assignments similar to the card matching activity. The students also indicated their interest and willingness to further investigate the flipped classroom model for future lessons, given some modifications to the model. After reflecting on the flipped classroom model created for these particular students, the teacher-researcher concluded that future action research cycles could investigate a flipped classroom model similar to that outlined by Bergmann and Sams (2012), using instructional videos recorded by the teacher.

The teacher-researcher along with the student-participants and her colleagues reflected on the data collected, using it as a stepping stone to continue adapting the

classroom environment and other mathematics classrooms at EHS into environments that better serve female students by using a more active and student-centered pedagogy.

Data Analysis

Just as the action research process is cyclical, the analysis of the data to uncover the patterns and themes was recursive. The teacher-researcher's field notes and the mid-unit questionnaire responses from the six female participants led to the focus group prompt that revealed some of the same, as well as additional, themes in the data. In collaboration, the teacher-researcher and the student-participants refined the list of benefits from their flipped classroom experiences to include the conclusion that the flipped model can increase differentiation of instruction, improve peer-to-peer collaboration and student-to-teacher interaction, increase student responsibility in learning, and vary student engagement with content material.

Quantitative Data Analysis

The data collected from the questionnaire provided quantitative information to help with the polyangulation of the qualitative data from the observational field notes and post-unit focus group session (Mertler, 2014). Using multiple sources of data collection provided support and verification of the data and the conclusions. To foster trust with the participants, mid-unit questionnaire responses were anonymous, with the students submitting their completed questionnaires into their class folders to be retrieved and transcribed without identifying the students. Available responses included 1 for "strongly disagree," 2 for "disagree," 3 for "neither agree not disagree," 4 for "agree" and 5 for "strongly agree." The mean for each of the Likert-scale questions was calculated using a Texas Instrument TI-84 graphing calculator statistics program.

Given the results of similar studies such as those by Clark (2013) and Strohmyer (2016) in which students indicated increased engagement, it was surprising in this study to see that only two students chose the option "agree" for the statement "The flipped classroom instruction is more engaging than traditional classroom instruction" and for the statement "I am more engaged with the content in a flipped classroom setting. No students chose "strongly agree" to either of those two statements. Table 1 presented above, as well as the qualitative observational field notes and focus group input, were key in identifying initial themes for this data set. Due to the design of the five-point Likert scale, any mean value above 3.5 was noted when analyzing the questionnaire, and this analysis led to the beginning of the thematic coding. The common terms and key phrases that emerged were: (a) communication, (b) participation in videos, (c) preference for the traditional model, (d) increased teacher interaction, and (e) collaboration. Further analysis from the open-ended questions, the field notes, and the focus group discussion with my participants led to more refined but similar categories.

Qualitative Data Analysis

In the open-ended portion of the mid-unit questionnaire, students suggested including a group review of the content before beginning the collaborative class assignments, a strategy that was implemented for the remainder of the flipped classroom model for the unit on limits. Additionally, student responses to the open-ended questions indicated approval of the fact that the instructional videos provided the ability to pause and rewind the lesson and were always available for watching again, but also showed that students saw them as impersonal. This dichotomy led to the theme that the flipped classroom model can provide ways to differentiate instruction. In observation field notes,

the teacher-researcher recorded student preferences for videos that did not include a class on the screen with the teacher. Some students also indicated their preference for the videos with the female presenter. In the post-unit focus group, the female students first indicated a preference for traditional teacher-led lessons, but went on to explain that they were open to the flipped classroom model if the videos were recorded by their teacher. The student-participants said they did enjoy learning together and working collaboratively on assignments during class time. From these comments emerged the evidence of the flipped model as a way to vary student engagement with content material and a strategy for improving peer-to-peer collaboration and student-to-teacher interaction. The highest means from the questionnaire – recorded for questions 5 and 14 – seen alongside students' comments during the focus group indicated there was an increase in the responsibility and participation on the part of students in the flipped classroom model.

The field notes and observer's comments were transcribed and entered into the NVivo program for qualitative data analysis to identify recurring words and phrases. The key words that emerged from this analysis were: opportunities; responsibility; collaboration; communication; interaction; and independent. The list of key words was presented to focus group participants, along with the initial list generated from the observations and questionnaire data. The students assisted with the refinement and grouping of the initial themes and key words into the final coding that was used to further organize the data. The reciprocity between the teacher-researcher and the student-participants demonstrated their collective goal in seeking change that will improve the local educational climate for these participants.

Coding

During the analysis of the informal discussions and the mid-unit questionnaire, the following phrases reoccurred frequently: (a) student independence, (b) collaboration, (c) communication and interaction, (d) increased access to the teacher, (e) class time for review, (f) preference for the traditional teaching model, (g) students' opinions of the videos, (h) increased student responsibility, and (i) participation in learning. As more data were collected in the form of observations recorded as field notes and the focus group session, saturation was attained and additional coding was not feasible (Fusch & Ness, 2015). At that stage, the analysis progressed as the teacher-researcher, in conjunction with student-participants, combined like topics and refined the list to primary themes of flipped classroom benefits. Specifically, the benefits were identified as: (a) increasing differentiation of instruction, (b) improving peer-to-peer collaboration and student-to-teacher interaction, (c) increasing student responsibility in learning, and (d) varying student engagement with content material. Explanations and evidence for each of these themes are provided in this section.

Ways to Increase Differentiation of Instruction Using the Flipped Model

After two weeks of conducting the calculus unit on limits using the flipped classroom model, the students answered a 20-item questionnaire. Question 18 was: What adjustments would you recommend to improve learning in the Flipped Classroom? Students provided anonymous written responses that suggested a number of options including:

- have a brief summary of the video every day in class;
- do a review of what we watched the next day before doing the classwork;

- go over an example in class before handing out the assignment to ensure students' understanding;
- have a 20-minute discussion at the beginning of class about the previous night's video;
- allow lessons a week ahead of time and make them all due at the end of the week;
- make a place in the class to watch the videos again before starting the classwork; and
- provide a time for students who didn't get to watch the videos at home to view them in class.

With the input of the student suggestions, the original flipped classroom model was modified to include three areas in the classroom that provided different opportunities for students, based on their individual needs. In one section, students could watch or re-watch the videos, while a second section was set aside for group review of the content presented in the video lessons. The third area was set up for use of those students who had the confidence to proceed with the application and practice of the content. This change allowed for differentiation for the students based on their level of understanding regarding the concepts presented in the video lessons.

During the post-unit focus group discussion, the theme of the class structure was repeated. For instance, Amy commented, "I didn't like how, at first, we watched the video, then the next day just did the work together. I'd rather do a little review before we start to make sure I'm on the right track." Maggie echoed the comment, saying "I second that. I had to go to the review for like the first 15 to 20 minutes before I started the

assignment, to know if, like, we are doing this right or we are doing this wrong." Likewise, Becky stated "I think the 15- to 20-minute recap at the beginning of class helped bring it together if we had any questions." Regarding the portion of class time allotted for students to watch or re-watch the videos in class time, Wendy commented, "I had to watch the videos in class a couple of times, because I had to work and could not watch the videos before class the next day." These statements provided evidence that the initial structure of the classroom was not conducive to the female student's needs, but demonstrated that the flipped classroom model provided the flexibility to make changes that gave the students choices based on their individual preparations and needs each day. The participants collectively decided the ability to make the adjustments to the class structure was a key feature behind their willingness to continue with any future investigations of the flipped classroom model.

Johnson (2013), Murray et al. (2015), and Ziegelmeier and Topaz (2015) had similar results, each reporting that the flipped classroom model allowed teachers to add strategies for differentiation, provided the flexibility of when and where students learned new content, and gave more time for different modes of active student learning.

Strategies to Improve Peer-to-Peer Collaboration and Student-to-Teacher Interaction using the Flipped Model

Several studies reviewed in Chapter 2 reported that using a flipped classroom model created more time to interact with students on a daily basis (Bergmann & Sams, 2012; Roshan & Roshan, 2012); that female students benefitted from the high degree of interactions (Bergmann & Sams, 2012); that students worked collaboratively to discuss problems, explain procedures, and confirm answers (Clark, 2013); that there was

improved peer-to-peer and student-teacher interaction (Goodwin & Miller, 2013; Murray et al., 2015; Strohmyer, 2016); and that students developed a learning community through discussions with their peers (Ziegelmeier & Topaz, 2015). Likewise, the data collected in this action research study from the mid-unit questionnaire and from the post-unit focus group discussion provided evidence that the flipped classroom model allowed for increased opportunities for learning in a social setting with increased interaction with peers and the teacher.

Peer-to-peer collaboration. The teacher-researcher divided the six students into two groups that served as their learning groups for the unit on limits. When students were involved in watching or re-watching the video lessons, some students worked with single partners instead of in their small groups. Observation field notes included recorded comments indicating that students worked successfully in collaboration to complete their class work during the flipped classroom model, communicating about their mathematical thought processes and sharing learning strategies with one another. For instance, on day 6 of the unit, Abby asked her group members for clarification about the cases where a limit has a denominator from which a factor cancels out with a factor in the numerator, inquiring whether that was the case of an asymptote or another type of limit that does not exist. Maggie was able to provide Abby with her own interpretation of this phenomenon, explaining:

> If you can cancel it out with the top, then it's not an asymptote, it's just like a hole in the graph. So, the limit does exist and you have to do substitution. At least that is what I gathered from the video anyway.

In their questionnaire responses, four of the six participants said selected "agree" for the statement "The flipped classroom gives me greater opportunities to communicate with other learners," and five of the six participants chose "agree" or "strongly agree" for the statement "The Flipped Classroom provided more opportunity to collaborate with other learners." During the focus group, Kerrie stated, "I liked working together during the flipped and felt more connected to the people in class." Wendy expressed similar sentiments, saying, "I like working together too and would like to do more [flipped] sometime, but maybe not a whole unit." Both Kerrie and Wendy are students who were typically quiet in the traditional, teacher-led classroom structure, but actively worked and communicated successfully in their cooperative group during the flipped classroom model.

Student-to-teacher interaction. In addition to the improvements with peer-to-peer interaction, there was an increase in teacher access during the class time with the flipped classroom model. In the traditional, teacher-led model, the teacher was occupied with teaching the lesson through a lecture to the whole class. Students would have to ask questions aloud in front of the entire class or wait until the teacher was free to address a question individually. Field notes during the flipped classroom model show increased teacher-awareness of the students' thought processes as they learned, as a result of being able to listen to their discussions with one another, ask for explanations regarding their thinking, and correct their mistakes immediately.

In questionnaire responses, only one student chose "disagree" for the statement "One-on-one interaction with my teacher increased with the flipped classroom." There was some contradictory data provided on the questionnaire as well. Five students chose

"agree" or "strongly agree" while one student chose "neither agree or disagree" for the statement "I feel sufficient opportunity was provided to ask questions to the teacher for clarification during the flipped classroom model." Also, when asked "What would you consider to be the advantages of the flipped classroom?" one female wrote, "I felt less alone when I was trying to learn something new and hard to learn." However, when asked "What would you consider to be the disadvantages of the flipped classroom?" four of the six students listed among the disadvantages the inability to have immediate access to the classroom teacher while watching the instructional videos. One student said the flipped classroom model was more impersonal, and another student expressed the opinion that the flipped classroom "lacks motivation that a real live teacher can provide."

Methods to Increase Student Responsibility in Learning Using a Flipped Model

Results from similar studies revealed that the flipped classroom model relied on students becoming more independent and self-paced critical thinkers who took responsibility for building their own understanding of the content (Goodwin & Miller, 2013; Roshan & Roshan, 2012; Strohmyer, 2016; Ziegelmeier & Topaz, 2015). The teacher-researcher in this study observed a transformation of student behavior and an increase in mathematical discourse. When working in a traditional, teacher-led classroom setting, the students were dependent on the teacher for answers. If they faced a question, their immediate response was to raise their hands or go to the teacher and ask for an explanation. However, during the flipped classroom model, the students became more responsible for their own learning. They gained confidence in their abilities to be the creators of their own learning and could better explain their thought processes while providing mathematical justifications for their ideas. When faced with misunderstandings,

the female students participating in the study first asked a peer for assistance. For example, one group was having trouble remembering how to factor the sum and difference of cubes. When all three members of the group admitted that they had forgotten this skill, they referenced their notes from the videos. After realizing they had not written that information in their notes, they searched the internet for a lesson on factoring the sums and differences of cubes. They learned to seek alternative sources rather than relying on the teacher for all mathematical knowledge. The role of the teacher shifted to that of facilitator as students increasingly showed independence in constructing their own learning. This observation was confirmed in the questionnaire responses, with all six female participants choosing "agree" or "strongly agree" for the statement "I am more responsible for my learning in a flipped classroom setting."

The teacher-researcher also observed an increase in the level of student responsibility required in a flipped classroom model. Outside of class time, students were responsible for gaining the content needed for the class assignment the next day, an issue that was challenging for two of the female students in particular. In the focus group discussion, Wendy admitted that watching the videos was especially challenging for her due to her afterschool job of watching young children. She explained that she could "squeeze in bookwork or worksheets for homework" because she can work on that type of assignment in other classes during the school day, but she cannot watch a video during another class. Similarly, Becky said that she was more likely to complete a "tangible worksheet" that she was required to physically turn in, since she deemed that to be more important. She did admit, though, that the videos were "probably the same level of

importance." Becky further described her experience with the flipped classroom model as follows:

> I prefer you [the teacher-researcher] teaching over the flipped classroom because if you happen to have a lot to do after school and are rushed to watch [the video], you are not going to soak it all in. Or you will say, 'oh, I'll just watch it in the morning,' but you know you're not going to watch it in the morning. So, it is good to just have that class time devoted to learning new stuff and not having to worry about scheduling it in your night. I can be more focused in class because I don't have anywhere else to be. So, I can focus on learning and not have to stop and go eat or whatever.

Once in class, students were responsible for knowing their preparation level in order to choose which station would suit their needs. In the focus group, Kerrie commented that "I was accountable for watching the video before class, but if I didn't watch it or understand it, I knew I could go the video watching station before I started the assignment."

Again, there was inconsistent data provided on the questionnaire regarding student perceptions of the increase in student responsibility. Two students listed the flipped model's dependence on responsibility as an advantage, while two other females listed it as a disadvantage of the flipped classroom model.

Ways to Vary Student Engagement with Content Material Using a Flipped Model

On several occasions throughout the study, the teacher-researcher and the student-participants discussed the sources and types of instructional videos and classroom assignments that were provided for the unit on limits. Field notes included observations

of the students' comments about the videos. Kerrie said, "The girl video was easier to understand, because she did not have a class behind her like the guy did." On her questionnaire, one female stated that "the videos were long and not exciting." During the focus group Maggie said, "I feel like the girl only did like a few examples. That's one thing I did not like. But the guy did a bunch of examples, like every single scenario, but the girl only did like a couple." The other girls indicated their agreement with Maggie's description. Amy said, "I think it would be better if [the teacher-researcher] made the videos. I liked how you could pause it and go back, but I think you do a better job of teaching. I learn better when you teach." Maggie agreed, saying, "I think it would be better if you made the video and taught the lesson. I just did not like the girl. She went so fast and the guy was so long. So, there was no good medium." Becky also said, "I would like if you made them." She further explained that "it is easier to learn from the particular voice you trust and associate with that topic and are used to that pace." Kerrie, who had prior experience with a flipped classroom model in a middle school English class commented on some of the lessons, saying, "I searched the topic and a whole bunch of [videos] popped up on the side. So, I watched some of them also. I found there was a lot of videos and resources out there."

The data showed mixed results concerning the in-class assignments. Two students indicated on their questionnaire that the collaborative classwork was an advantage of the flipped classroom model. In contrast, only two females choose "agree" in response to the statement "I am more engaged with the content in a flipped classroom setting." In the focus group, Wendy said, "I preferred the card matching and the graph drawing lessons over worksheets, because I felt like we were applying what we knew and it was more

hands-on." In the review of existing literature, multiple studies reported that student engagement and participation increased with more hands-on learning activities during which students used class time for activities that provided opportunities for learning by doing rather than spending class time engaged in passive listening (Clark, 2012; Day & Foley, 2006; Goodwin & Miller, 2013; Strohmyer, 2016; Ziegelmeier & Topaz, 2015).

Data Interpretation

The teacher-researcher collected data in the form of informal observations recorded as field notes, response to mid-unit student questionnaires, and input from a post-unit focus group session with student-participants, with the goal of presenting an accurate portrayal of the female participants' perceptions of the flipped classroom model in their AP calculus class. The female participants provided feedback throughout the study to help guide the progression of this cycle of action research. To create a student-centered mathematics classroom based in constructivist and social constructivist principles and using active and interactive learning strategies, the teacher-researcher developed a flipped classroom model where students would learn new content via YouTube instructional videos outside of the class time, reserving the scheduled class time for collaborative practice (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). Halfway through the unit on limits, the students completed a questionnaire (Appendix E). Student responses are displayed below in Figure 4.2.

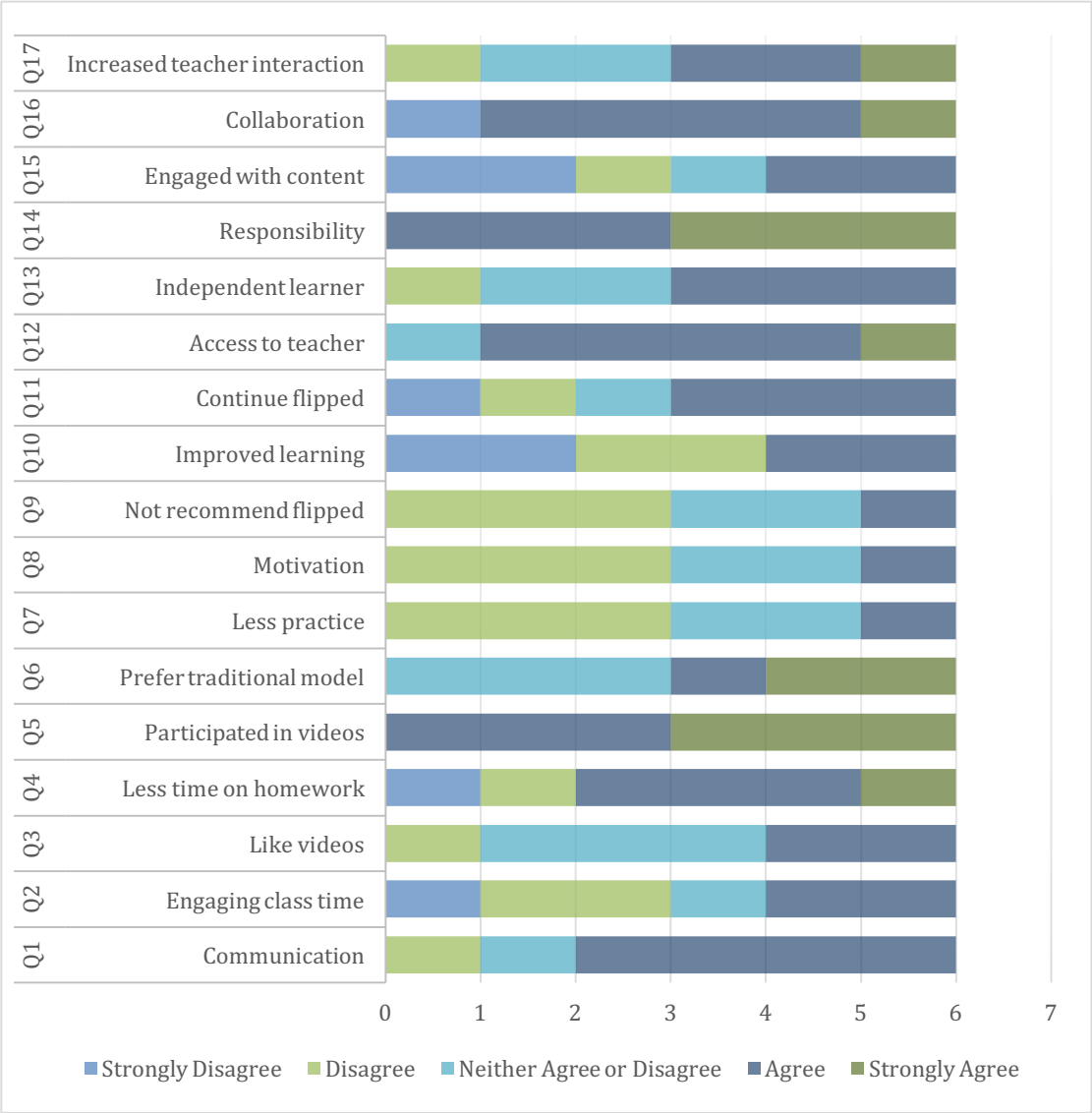

Figure 4.2. Questionnaire Results: Student Perceptions of the Flipped Classroom Model

The stacked bar graph in Figure 4.2 visually displays how the initial themes of communication, teacher interaction, learner independence, student responsibility, and collaboration were identified. These themes were verified using the qualitative data gathered from questions 18, 19, and 20 on the questionnaire, from teacher observations, and from focus group input. The qualitative data were analyzed using a word frequency

query in NVivo software that identified additional themes of opportunity, types of videos, and class structure. In the focus group session, student-participants assisted with the thematic coding of the qualitative data that yielded four primary outcomes from the flipped classroom investigation. The flipped classroom was found to provide the teacher with: (a) ways to increase differentiation of instruction, (b) strategies to use to improve peer-to-peer collaboration and student-to-teacher interaction, (c) methods to incorporate to increase student responsibility in learning, and (d) ways to vary student engagement with content material.

Student Experiences and Preferences

The mid-unit questionnaire responses revealed that while these female student-participants indicated either neutrality or a preference for traditional, teacher-led classroom structures over the flipped classroom model, they acknowledged advantages to the flipped classroom model linked to their priorities of collaboration and interaction, as indicated by their answers to questions 18, 19, and 20 on the questionnaire and by their comments during the focus group session. During the focus group, the students provided more detail regarding their perceptions. They expressed their preferences for in-class activities over traditional practice. The females also indicated their willingness to continue investigating the flipped classroom model with some modifications. Specifically, they indicated their preference for teacher-created instructional videos in place of online YouTube videos.

Field notes and focus group input confirmed that the majority of participating students were unfamiliar with the flipped classroom pedagogical strategy used in mathematics, and were, instead, accustomed to a teacher-centered, whole-class, lecture-

based environment. For the flipped classroom model, students indicated the importance of coming to class prepared by watching the assigned videos, which they could review at the beginning of class and then go on to participate in the collaborative assignments during class time. To continue with a flipped model, these students would need further training in time management in order to fulfill their responsibilities prior to class.

The teacher-researcher informal observations recorded as field notes, the mid-unit questionnaire responses, and the post-unit focus group discussions revealed an increase in students' participation in the construction of their knowledge of mathematics. Students displayed confidence in justifying their mathematical thinking throughout the mathematical discourse that occurred during their collaborative work. The Flipped Classroom Model for this cycle of the action research study allowed for a classroom environment that enabled these female students to increase their personal responsibility for learning and improve their confidence in this advanced mathematics course. Students agreed to further investigations of a Flipped Classroom Model with some suggestions for adjustments according to their specific preferences.

Answering the Research Question

The teacher-researcher sought to improve classroom practice by increasing student-centered and active learning strategies for six female students in an AP calculus class. The teacher-researcher taught a calculus unit on limits using the flipped classroom model and collected qualitative data concerning the student-participants' perceptions of this teaching strategy. Data were collected in the form of informal observations recorded as field notes, responses to a questionnaire, and input from a focus group discussion. After analyzing the data collected, the teacher-researcher could answer the research

question: *What are female calculus students' perceptions of the flipped classroom model?* Evidence from the mid-unit questionnaire and focus group session revealed that though the female students initially preferred the traditional classroom structure they were already familiar with when learning new mathematical content, they indicated their collective interest in future investigation with the flipped classroom model, given specific modifications such as adding teacher-made video lessons during their post-unit focus group session. The students indicated a desire for more experience with some lessons using the flipped model, but expressed unwillingness about experiencing an entire course structured according to the flipped model. The students expressed favorable opinions concerning the social aspects of the flipped classroom model, indicating that they enjoyed the increased peer-to-peer collaboration during the class assignments and that they appreciated the improved opportunity for interaction with the teacher during class time (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013; Murray et al., 2015; Strayer, 2007; Ziegelmeier & Topaz, 2015). Thus, the female students had mixed, unfavorable then encouraging, perceptions of the overall flipped classroom phenomenon in their calculus class.

Given the small sample size for this action research cycle, there is no intention of generalizing the results from this action research study beyond this specific group of student-participants; however, the teacher-researcher shared the findings from the data during the focus group discussion with the female student-participants from the flipped classroom model and facilitated an open discussion about the meaning of those results for the design of future units in the school's AP calculus courses. Furthermore, the teacher-researcher developed a brief PowerPoint presentation reporting the data collected and

summarizing study findings and students' interpretations of the findings, sharing the report with colleagues in the mathematics department and with the district curriculum coordinator at a monthly collaboration meeting. The PowerPoint presentation shared specific information concerning the student-centered environment, the positive social interaction, and the increased active learning that arose from the flipped classroom phenomenon, and also shared the key questions that arose during this action research cycle which was similar to findings of Bergmann & Sams (2012) and Clark (2013). During the meeting, the mathematics teachers were given time to discuss the flipped classroom model, the results from this action research study, potential benefits of the flipped methodology, and other student-centered pedagogies that EHS teachers could explore via future action research. An action plan was developed to continue investigating the flipped classroom model in the spring of 2018 in the teacher-researcher's calculus classes, potentially expanding the investigation to other calculus classrooms at EHS the following fall.

Conclusion to Chapter 4

The purpose of this action research study was to investigate the flipped classroom model as a potential strategy for improving the teacher-researcher's practices towards student-centered methods that can provide female students with better access and improved understanding of mathematics by increasing their active learning in the calculus classroom. Through the collection of evidence using informal classroom observations, responses to a mid-unit questionnaire, and input from a post-unit focus group discussion, the action research study gave student-participants a voice concerning their experiences with the flipped classroom model in advanced mathematics. Chapter 4

outlined the data collection methods as well as the findings and interpretation of the data collected. The qualitative data were analyzed using thematic coding and revealed supportive evidence that the flipped classroom model offers ways to (a) increase differentiation of instruction, (b) provide strategies to improve peer-to-peer collaboration and student-to-teacher interaction, (c) increase student responsibility in learning, and (d) provide ways to vary student engagement with content material. The predominant finding of this action research study was that the female students had favorable views of the flexibility and social aspects that the flipped classroom can provide.

The teacher-researcher, along with the student-participants, used the action research process to raise key questions for future study, analyzed the data collected, and reflected on the findings to develop an action plan for these particular classes to benefit their collective educational experiences in mathematics. As stakeholders in the action research process, the students were provided a voice during the classroom debriefings, through the mid-unit questionnaire, and in the post-unit focus group session. Since there was some evidence that the female students wanted additional exploration with the flipped classroom model, the teacher-researcher will continue to investigate this pedagogy with modifications suggested by the students in a future action research cycle in the spring semester of 2018. The cycle of action research will continue as the teacher-researcher seeks to be a change agent for more effective practices to empower female students to be more active learners as they construct their knowledge of higher-level mathematics. Chapter 5 will detail the action plan devised with other calculus teachers at the high school and with the district mathematics instructional specialist using the input of the student-participants and the findings of this action research inquiry.

Chapter 5: Summary, Conclusions, and Action Plan

Introduction to Chapter 5

Mathematics teachers at EHS have relied on traditional, teacher-centered pedagogy. The high school is set in a rural district in the upstate region of South Carolina. This action research study evaluated female students' perceptions of the flipped classroom model as a means to reform pedagogy to a student-centered approach using active-learning strategies. The flipped classroom model is one in which introduction of content is moved outside of the classroom as homework to provide time in class for active group and partner assignments designed for practice, extension, and enrichment.

Six female, 12th grade, AP calculus students at EHS served as the student-participants for this action research study. In order to create a student-centered environment, supported by constructivist and social constructivist ideals, for underrepresented female students in advanced mathematics, the teacher-researcher askes the following question: What are female calculus students' perceptions of the flipped classroom model? The flipped classroom model was implemented during a four-week calculus unit on limits during the fall of 2017. Student-participants watched direct instruction videos outside of class time and participated in collaborative assignments during class time. The teacher-researcher collected qualitative data using daily informal classroom observations recorded as field notes and from a post-unit focus group discussion, and collected quantitative data using a mid-unit questionnaire. The data collected was used to describe the phenomenon the six females experienced with the

flipped classroom model in AP calculus and to gather their perceptions regarding the classroom model. Transcriptions from the informal field notes, the three open-ended questionnaire questions, and the focus group discussion were entered into the thematic coding analysis software NVivo. The quantitative data from the 17 Likert-scale questions were used to poly-angulate the qualitative themes (Mertler, 2014). The software identified the most frequent phrasing, which was summarized to report findings that the flipped classroom model can (a) provide ways to increase differentiation of instruction, (b) provide strategies for improving peer-to-peer collaboration and student-to-teacher interaction, (c) offer methods for increasing student responsibility in learning, and (d) suggests methods for varying student engagement with content material. At the outset of the study, student-participants expressed a preference for the traditional classroom structure with which they were most familiar, but by the end of the action researcher, expressed an interest in investigating the flipped classroom strategies in future lessons with modifications to the original model used for this study. They also expressed favorable opinions regarding the collaborative activities and increased social interaction elements provided by the flipped classroom model. In Chapter 5, the findings are linked to the original problem of practice and explained in the context of the related literature. Chapter 5 also presents the key questions that emerged from the findings, explains the development of the Action Plan, and offers future research suggestions.

Key Questions

Three key questions arose from this action research study. During the focus groups, student-participants expressed their willingness to continue with the flipped classroom model for future lessons, but suggested that the online videos be replaced by

instruction recorded by their classroom teacher. Existing literature, however, noted that the additional time required for recording and editing videos, combined with the time required to plan class activities, is a drawback to operating a flipped classroom model (Herreid & Schiller, 2013; McGivney-Burelle & Xue, 2013). In order to address the student-participants' requests for teacher-made videos, the mathematics teacher who will participate in the next phase of the action plan during the spring of 2018 will need training in the creation of videos using the technology available through EHS. Therefore, the first question to address is the question of which future elements of the flipped classroom model can be strengthened for future implementation? The data for this study found that flipped classroom model contributed strategies for differentiating instruction, raising a second question regarding the motivations that would be needed to encourage students to use the technology to watch their lessons prior to class time. The literature review revealed studies that included a self-paced mastery component with built in assessments as one possible answer to this question (Bergmann & Sams, 2012; Clark, 2013; Roshan & Roshan, 2012). The study left the teacher-researcher with questions as to whether allowing for self-paced progression with independent assessment checkpoints built in or with guided notes might benefit the student participants, or whether it would detract from the collaborative and active learning community that was the goal of the study. As a curriculum leader in the mathematics department at EHS, the teacher-researcher also faced the question of how best to help other teachers use the flipped classroom structure to enable their students to grow and develop within the school's calculus courses? It is the teacher-researcher's intention to gather and share data regarding the experiences of the six female study participants in an effort to involve more

teachers at EHS in the use of teaching strategies that better prepare students to be builders of their own knowledge.

Action Researcher

The inquiry into the perceptions of Female Calculus students regarding the flipped classroom model was designed to include the student-participants in the experience of designing of a student-centered pedagogy and active environment for their calculus classroom. The researcher in this action research study also serves as the teacher for the class, and therefore is also an insider and member of the learning community involved in the study. As an insider and classroom teacher, the teacher-researcher is invested in the mission of improving classroom practices and can therefore benefit from that position by building a knowledge base from which to inform the learning community (Herr & Anderson, 2005).

The teacher-researcher had the advantage of having taught AP calculus to students with backgrounds similar to those of the student-participants, enjoying a working inside knowledge of the situation that an outsider might not have. However, that knowledge and familiarity could lead to bias regarding practices and outcomes. The teacher-researcher, therefore, in order to inhibit potential insider bias, acknowledged the challenges related to direct involvement in the study as an insider, engaging in self-reflection when reviewing daily field notes and engaging in co-reflection with student participants through informal conversations throughout the study (Herr & Anderson, 2005).

The dual roles of outsider/researcher and insider/instructor created challenges for the responsibility for recording the informal observations, with the teacher-researcher

juggling the recording responsibility with the responsibility for acting as teacher in the flipped classroom. Tedlock (2000) argued that observations from a participant cannot be objective because they are a co-construction of the observer and the observed, so maintaining the perspective of an outsider was an additional obstacle when collecting and analyzing the data for this study. A possible solution would be to record class sessions, allowing the teacher to maintain full attention when interacting with the student-participants and to record observation data later. Without taking that step, the teacher-researcher needed to develop data collection methods that would work in the context of serving as both researcher and classroom teacher. In this case, the teacher-researcher wrote up observations and field notes as often, as accurately, with as little bias as possible during class time, while using informal questions to reflect with the students concerning their attitudes about their experiences. During planning time following the class meeting, the teacher-researcher interpreted class observations and added commentary to the notes taken during class regarding feelings and thoughts about the flipped classroom structure and how the students were responding to the active learning strategies. For instance, field notes taken during classroom observation expressed hopes that the students would learn from the videos and enjoy the change in the traditional pedagogy, but in making additions after the class time, the teacher-researcher recorded students' feelings of dislike and apprehension about the instructional strategies and their comments about not understanding parts of the videos. Like the students in the Strayer (2007) study, the study participants were initially unsettled when participating in the flipped classroom, but later gained familiarity with and confidence in the class structure. In the role of insider, the teacher-researcher worked to retain objectivity and avoid pushing any particular agenda,

so that the data accurately described the experiences of the female participants. In the role of outsider, however, the teacher-researcher worked to make sure that experiences were viewed through an unbiased lens so that discoveries and findings reflected the reality of the phenomenon.

While not all students expressed positive emotional outcomes from experiencing the flipped classroom model as it was designed for this study, they indicated a preference for the active learning that took place in the classroom during the calculus unit on limits. The teacher-researcher realized that the original model designed for the class proved not to be an effective one. Therefore, to address educational change, the teacher-researcher would need to use the collected data as the basis for future decisions and as the basis for adjustments to the model in order to meet the needs of students. When sharing the data and findings from this action research cycle with the other mathematics teachers at EHS, the teacher-researcher met with a reluctance to change and with concerns regarding the flipped classroom pedagogy on the part of some teachers. Their concerns included time constraints, the lack of familiarity with developing the active learning strategies, and the use of technology that would be required to implement flipped lessons. However, the two calculus teachers have expressed willingness to consider incorporating some flipped lessons in their fall 2018 calculus courses to improve their professional practice by creating more student-centered environments.

Developing an Action Plan

Mertler (2014) explains that one of the five most common outcomes of an action research study is that "a plan, a program, or an instructional method is found to need modification" (p. 211), and such proved to be the case with this action research cycle. To

continue the pursuit of a teaching strategy that includes active learning strategies, the teacher-researcher was guided in the development of the action plan by reflection on the findings that emerged from the data in this action research study. For instance, the students expressed favorable opinions about the increase in the interaction with their peers and the teacher and with the collaborative classroom activities they experienced during the flipped classroom model. While the student-participants suggested in their questionnaire responses that they preferred a traditional, teacher-led classroom structure to the implemented flipped classroom model, they later revealed during member-checking in the focus group discussion that the unfavorable responses were due to their unfamiliarity with the flipped classroom structure and their criticisms of the video lessons that were chosen for the calculus unit on limits. In focus group responses, the female students indicated their interest in further investigation of the flipped classroom, given some modifications to the instructional model. To increase their engagement with the instructional video content, the student-participants recommended that the teacher create the videos rather than choosing online videos featuring other instructors. In response, and intending to continue addressing the initial need for a student-centered classroom pedagogy, the teacher-researcher used input from the student-participants to develop an action plan involving modifications to the flipped classroom instructional method. The action plan is presented in the next section.

The Action Plan

Justification

Though the flipped classroom model designed for this action research cycle did not provide an unflawed answer to the problem of creating a student-centered pedagogy,

it did offer a springboard upon which to build more active experiences where the female student-participants could co-construct their mathematical understanding. The data collected from the student responses to the questionnaire was inconclusive regarding their perceptions of the flipped classroom, but coupled with the focus group discussion, results were similar to those of the Strayer (2007) study. Students participating in this study expressed apprehension about the model because of their lack of familiarity with the pedagogy, because of the types of instructional videos suggested, and because the structure of the flipped model did not include a review of the video lessons prior to the working on in-class assignments. Bruner (1966/2013) suggested encouraging students to discover their competency on their own by providing the opportunity to develop confidence in their abilities independent of the teacher. It is the teacher-researcher's contention, based on experiences with this study, that students will gain expertise and understanding with continued experience with the flipped structure. Moving the direct instruction out of the classroom allowed for a student-centered classroom environment, where assignments that promoted an increase in the social interaction and communication between the students were completed as they made meaning of the content as a community of learners. The student-participants' favorable opinions of the active learning strategies used with the collaborative in-class assignments assisted in the decision to continue pursuing the flipped classroom option with adjustments for future lessons with these particular students.

Technology In-Service, January 2018

Per Mertler (2014), the teacher-researcher reflected on suggestions and worked with student-participants to formulate an action plan that would investigate the flipped

classroom with modifications to strengthen the model, including teacher-made videos and a differentiated classroom structure allowing for questions and review of the out-of-class video lessons. The instructional videos in the flipped structure serve as materials with which students can interact actively rather than passively as an essential element to the unit design (Bruner, 1966/2013). Brame (2013) noted that teachers can use online sources for their flipped classroom videos or employ a more personal touch by creating their own videos. In the focus group discussion, participating students in this action research study requested teacher-made videos, a request that has been incorporated into the action plan for the spring semester of 2018. The teacher-researcher engaged in multiple meetings with the school's technology integration specialist to obtain assistance in developing videos using the school's available technology. It was determined that the most efficient method for making the teacher-led instructional videos would be to use the ActivInspire software by Promethean, since it has a built-in screen capture feature that would record the teacher's writing on the screen, any additional applications used by the teacher (graphing calculators, for example), as well as the sound, while also allowing the presenter to pause as needed. The teacher-researcher could use the ActivInspire flipcharts previously developed for in-class direct instruction, while explaining the thought process for the students and demonstrating the examples while recording the lessons for students to view at home.

Modification to the Flipped Model for February-March 2018

Dewey (1938) recommended teachers designing student-centered environments to create experiences that inspire students to learn. In addition to creating an environment in which female learners can interact with the content using more active strategies,

Vygotsky (1978) emphasized that "human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them" (p.39). The modified flipped model will provide female students with the opportunity to participate in making meaning of advanced mathematics while developing their skills together as a community of learners. The teacher-researcher intends to implement the modification of the flipped classroom model in future lessons during March and April of 2018 for the same student participants, adjusting the model to include teacher-made videos and continuing to explore the application of social constructivist principles in the creation of student-centered collaborative learning experiences. For this cycle of the action research, the teacher-researcher will record a series of video lessons during February and March of 2018, for use with the future calculus unit on volumes. During the same timeframe, the teacher-researcher will design classroom assignments that rely on collaborative efforts of the student-participants so they can build their learning together.

Phase II of Action Research in April 2018

In April 2018, the teacher-researcher will teach the calculus unit on volumes using the modified flipped classroom intervention with the female students who participated in the first phase of the action research. The female students will be instructed to watch the teacher-made videos outside of class time to prepare them for solving problems inside the classroom with a partner or small group. As suggested by Dewey (1938), the classroom environment will include assignments that allow students to draw from their prior knowledge of finding area by adding an infinite sum of lengths and use that prior knowledge to construct their strategies for finding volumes of irregular solids formed by mathematical equations.

Phase II Action Research Methodology for April and May 2018

Since the same participants will be involved in the next phase of the study, the consent forms obtained in August 2017 will cover the next phase of the research taking place in the spring of 2018. The teacher-researcher will maintain field notes to capture the action that occurs in the classroom and to record teacher observations and reflections throughout the next action research cycle (Dana & Yendol-Hoppey, 2014). Because the first phase of the action research inquiry revealed the difficulty of recording field notes during class time, the flipped classes will be video recorded in the next phase of research, providing the opportunity for the teacher-researcher to transcribe classroom experiences after the fact, ensuring full engagement with the students during class time. The second phase will also include a questionnaire of survey designed to elicit student perceptions of the modified flipped classroom model. As Dana and Yendol-Hoppey (2014) suggested, "surveys can give students a space to share their thoughts and opinions about a teaching technique or strategy, a unit, or their knowledge about particular subject matter" (p. 114). The questionnaire in the second phase will eliminate the neutral response choice offered on the questionnaire during the first phase, with students given four responses choices on the Likert scale instead of the five response choices included during the first phase. The teacher-researcher concluded that the focus group provided an opportunity for student-participants to honestly report their specific experiences and verbalize their opinions in a safe setting, and therefore decided to conduct a focus group session with the participants after completion of the volume unit in the next phase as well. After collecting data from the second phase of the action plan, the teacher-researcher will again analyze data for recurring themes, and share findings with the participants and the mathematics teachers at

EHS during the summer in-service time, with the goal of impacting the student-centered culture in the school's mathematics classrooms in ways that better serve female students.

Mathematics Department In-Service, June 2018

Wasley (1992) defined teacher leadership as "influencing and engaging colleagues toward improved practice" (p.21). The EHS mathematics department instructors meet each summer for collaborative planning and sharing. A meeting date during the summer of 2018 will be set aside to conduct a round table for sharing teaching ideas, with 15 teachers, one administrator, and the district mathematics instructional specialist participating in the discussion. Findings from this study will be among the topics shared at the meeting, with the teacher-researcher reporting the perceptions of the study participants regarding their perceptions of the flipped classroom phenomenon they experienced during the 2017-2018 school year. The teacher-researcher will also meet with the school's other two calculus teachers in a specific subject-matter breakout session to determine the future lessons that will be adapted to a flipped classroom structure in order to better serve female students during the 2018-2019 school year. Summer in-service time will be used to create videos and in-class activities for the calculus units that will be taught using the flipped model, with the teacher-researcher providing technical support and professional development to any additional teachers that express an interest in developing their practice using the flipped pedagogy in the fall of 2018. Mathematics teachers will meet on a monthly basis to monitor any effects of the flipped strategies.

District Numeracy Team In-service, September 2018

The Eagle school district maintains a numeracy team, the purpose of which is to collaborate across grade levels to grow, share, and develop mathematical knowledge and

mathematics programs in ways that help students leave the school's mathematics classrooms with a greater understanding of mathematics and realizing mathematics' relevance in their own lives. The team consists of the district's mathematics instructional specialist and teachers representing each school and grade level from the district. As a member of the district numeracy team, the teacher-researcher will present the findings of this action research study to the other teacher-leaders on this team, equipping them to disseminate relevant information to their respective schools and departments.

Facilitating Educational Change

Individual Classroom Change

Mills (2014) observed that "the goal of action research is to enhance the lives of students and teachers through positive educational change" (p. 172). Bergman and Sams (2012) indicated that female students can benefit from the flipped classroom approach because of the model's increased interactions with peers and with the teacher, and as a result of the model's flexibility and increased opportunities for self-paced learning. The current action research study, however, yielded mixed results regarding the perceptions of the female student-participants about the flipped classroom model (Bishop & Verleger, 2013; Ziegelmeier & Topaz, 2015). In questionnaire responses, only one of the students responded that she was motivated as a result of using the flipped model and indicated that she would recommend the flipped structure. In contrast, a total of five participants responded in the focus group discussion in ways that indicated an interest in continuing to learn using the flipped classroom model strategies. The student-participants reflected on their experiences with the flipped model and shared their suggestions for improving the phenomenon to enhance their understanding of mathematics and opinions about the

flipped structure. Based on participant input, the teacher-researcher determined to continue investigating the same students' perceptions of the flipped classroom during the spring of 2018, modifying the model to use teacher-made instructional videos, as suggested by the participants and as noted in previous studies (Bergman & Sams, 2012; Clark, 2013; Johnson, 2013; Renfro, 2014). Making those specific modifications pose a time challenge as the teacher-researcher seeks to record the instructional videos and create in-class active learning based activities and assignments for use in the calculus unit on volumes in April 2018. However, the necessary motivation for accomplishing those additional, time-consuming tasks comes from the teacher-researcher's commitment to the goal of improving teaching practices toward a student-centered approach.

School-Wide Change

With the support of the school administration, teachers can contribute to educational reform within a bottom-up power structure by working from the classroom as curriculum leaders (Mills, 2014). As a member of the mathematics department at EHS, the teacher-researcher included a commitment in the second part of the action plan to share the knowledge gained from the inquiry with other colleagues so that the department can alter classroom practices to benefit the learning experiences of young females in advanced mathematics (Dana & Yendol-Hoppey, 2014). This action research study yielded findings that argue for the potential of the flipped model to (a) increase the differentiation of instruction, (b) improve peer-to-peer and student-to-teacher interactions, (c) increase student responsibility, and (d) provide variety in the methods used to engage students with mathematical content. As Renfro (2014) noted, the flipped classroom, "like any pedagogical tool … has its strengths, potential, weaknesses, and

limitations regarding its utility" (p.503). Implementing changes to pedagogy such as the flipped classroom model requires an investment of additional time. To alleviate the apprehension teachers may experience if they worked in isolation to make these changes, the teacher-researcher will initiate a Google Drive folder within the school's mathematics department online share site, providing a place where teachers can operate as a community of learners by uploading their lessons, instructional videos, activities, and assignments. While teachers may be reluctant to make changes in their teaching styles or participate in data collection, the district mathematics instructional specialist has encouraged all mathematics teachers to be willing to try to improve their practices to include more active, student-centered learning strategies. With this district-level support, the teacher-researcher hopes that EHS mathematics teachers will embrace their power to make informed educational decisions that will positively impact the learning culture for the school's female students by developing strategies such as the flipped classroom that offer interactive, collaborative and student-centered approaches.

Summary of Research Findings

The purpose of this action research study was to improve the teaching practices of the teacher-researcher by investigating a student-centered teaching strategy called the flipped classroom that is based in constructivist principles, where students actively building on prior learning and experiences for current and future learning and development (Dewey, 1938), and social constructivist ideals, where students work as a community of learners to collaboratively build their learning (Vygotsky, 1978), and to describe the female students' perceptions of their experiences with the flipped model (Clark, 2013; Johnson, 2013; McGivney-Burelle & Xue, 2013). The teacher-researcher

used the flipped strategy, a model that involves assigning students to watch instructional videos introducing new content outside of the classroom, while devoting time inside the classroom for collaborative learning experiences. For this action research study, the teacher-researcher implemented the flipped classroom model for six female students enrolled in a calculus unit on limits during the fall of the 2017-2018 school year. Data were collected from teacher observations recorded as field notes, from responses to a mid-unit questionnaire, and input gathered in a post-unit focus group. In findings that aligned with those of previous studies on the subject, four of the six participants listed improved interaction with the teacher as a benefit of the flipped classroom, five of the six participants indicated that they experienced increased collaboration with other learners, and all six participants indicated that the flipped structure created a classroom centered more on student responsibility for learning (Bergmann & Sams, 2012; Chen et al., 2016; Clark, 2013; Goodwin & Miller, 2013; Strohmyer, 2016; Ziegelmeier & Topaz, 2015). Observation field notes and questionnaire responses yielded evidence that the flipped model allowed for differentiation of instruction based on learning styles and improved student engagement with the content through collaborative exercises and problem-solving in class (Clark, 2013; Goodwin & Miller, 2013; Johnson, 2013; Murray et al., 2015; Ziegelmeier & Topaz, 2015). The teacher-researcher also observed that students improved in their mathematical discourse as a result of the collaborative classroom activities in which they had to explain their thought processes and justify their choices to their peers (Clark, 2013).

Midway through the unit on limits, the six female students answered 17 Likert-scale questions and three open-ended questions on a questionnaire (see Appendix E). At

that point during the action research, no student responded with disagreement to the statement that that they would rather watch a teacher led lesson than a video lesson. Four of the six participants also indicated that they did not like being unable to ask questions of their teachers as they watched the instructional videos, mirroring responses of participants in McGivney-Burelle and Xue's (2013) study. These four participants recommended that the flipped model be adjusted to include a debriefing of the instructional videos at the beginning of each class prior to the practice and application of the content. After making the adjustment with the classroom structure to allow for a summary and review of the instructional video at the beginning of class, the teacher-researcher noticed an increase in the confidence of the students as they approached their assignments. Upon completion of the limits unit, the teacher-researcher facilitated a focus group discussion that revealed an initial discomfort on the part of students toward the flipped model as a result of their unfamiliarity with a learning strategy that moves from passive attainment of knowledge from the teacher and toward student responsibility for actively creating their own knowledge. Two of the participants indicated that they had difficulty finding time and motivation to watch the videos outside of class, which is a key element of the flipped classroom. To adjust for that, the teacher-researcher permitted students to watch their video lessons during class time, which delayed their participation in the collaborative assignments in which they worked with partners or in groups to create possible graphs given specific characteristics using limits. This study showed that the flipped mode's dependence on content delivery outside of the classroom could pose logistical difficulties. Bergmann and Sams (2012) addressed this problem by including a self-paced mastery element. The teacher-researcher noted the fact that permitting students

to use class time for completing the homework assignment of watching the instructional videos would take class time away from the collaborative activities that allow students to actively make meaning of their content with practice, application, and exploration. McGivney-Burelle and Xue (2013) suggested using an entrance quiz to hold students accountable and to motivate students to watch their videos prior to class.

During the focus group, student-participants indicated their interest in learning future content with the flipped strategies, given a modification to the model in which the instructional videos would be created by their teacher. One student explained that it would be easier to learn from a voice that student already trusted and associated with the topic. This modification will be incorporated in the second phase of this action research study. Roshan and Roshan (2012) reported that the calculus students participating in their study expressed mixed feelings when first experiencing learning using the flipped model, but later reported less anxiety about learning in the flipped environment. In this action research, five student participants provided focus group input indicating that they enjoyed the classroom activities and that they grew more comfortable throughout the unit on limits as a product of learning new content using the flipped classroom model.

Suggestions for Future Research

While this inquiry adds to the literature base by investigating situational interest in a flipped classroom model with a focus on the opinions of underrepresented females in advanced mathematics, there is more to be explored using the flipped model as a teaching strategy based in constructivist and social constructivist principles such as Dewey's (1938) suggestion for a student-centered environment and Vygotsky's (1978) emphasis on social interaction. For instance, as suggested by the data collected in the first phase of

this inquiry, I will employ action research again to investigate student perceptions of the flipped model by strengthening the instructional video component by using teacher-made videos during the second phase of my action plan (Brame, 2013). This type of study will assist in determining if the students' opinions about the flipped classroom can be attributed to the instructional materials or the flipped teaching strategy employed. An additional suggestion would be to conduct a study that addresses the motivation for students to watch instructional videos for homework. A researcher could assess their learning prior to class or at the beginning of class in order to determine whether the flipped model holds students accountable and impacts the consistency with which they complete their out-of-class assignments. The teacher could use the iterative nature of action research to investigate various elements of the flipped classroom to unfold a model that will best suit the needs of her students in this particular setting. Due to concerns at EHS regarding test scores, the researcher would recommend an action research study designed to gather quantitative data regarding the impact of the flipped classroom model on academic achievement for mathematics students in a rural high school setting. Other studies have focused on the effects of the flipped classroom on student outcomes, but the literature is lacking in studies that examine the issue in a rural environment (Clark, 2013; Overmyer, 2014; Roshan & Roshan, 2012). Other underrepresented populations could be the focus of future studies regarding perceptions and academic outcomes related to the flipped classroom model.

Conclusion to Chapter 5

Mathematics courses at EHS, located in a rural region of upstate South Carolina, have relied on traditional, teacher-centered strategies in which new material is presented

in lectures, and application is attempted independently at home. This action research study sought to improve the teaching practices to include strategies that rely on constructivist principles, making the mathematics environment more student-centered (Dewey, 1938), and creating an environment where students can interact and collaborate as they make meaning as a community of learners (Vygotsky, 1978; Bruner, 1966/2013). The flipped classroom model is a pedagogical strategy in which the traditional American classroom paradigm is shifted or so that the introduction of content occurs outside of the four walls of the classroom via pre-recorded instructional videos, and class time is devoted to providing opportunities for students to have increased access to their peers and their teacher as resources while they participate in active and collaborative practice, exploration, application and co-construction of the content.

For this action research study, the teacher-researcher implemented the flipped classroom model in the fall semester of 2017 with six female calculus student participants at EHS and gathered their perceptions of the flipped classroom phenomenon. The teacher-researcher taught a calculus unit on limits using the flipped structure, assigning students to watch YouTube instructional videos outside of the classroom as an introduction to the content. During class time, the students worked with partners or in small groups to complete assignments and solve problems applying the properties of limits. Data were gathered in the form of teacher observations recorded as field notes, responses to a mid-unit questionnaire, and input from a post-unit focus group discussion. The teacher-researcher used NVivo software to analyze the qualitative data from the field notes, from the three open-ended questions in the mid-unit questionnaire, and from the focus group transcripts to identify common phrases and determine themes in student

responses. The quantitative data from the 17 Likert-scale questionnaire inquiries assisted with the poly-angulation of the data to provide a broader understanding of the flipped phenomenon with these particular female students (Mertler, 2014).

The NVivo analysis yielded four themes or benefits of the flipped classroom model. First, by opening up the class time together, the Flipped model provides the teacher with ways that he or she can differentiate instruction to match a greater variety of learning styles (Johnson, 2013; Murray et al., 2015; Ziegelmeier & Topaz, 2015). Next, the flipped model provides class time for the teacher to interact daily with each student and for students to engage in peer-to-peer collaboration, both of which cater toward female learning styles (Boaler, 2002; Brown et al., 2017; Bergman & Sams, 2012; Chen et al., 2016; Clark, 2013; Roshan & Roshan, 2012; Ziegelmeier & Topaz, 2015). Thirdly, the flipped model increased student responsibility as a result of changing from a format in which students passively receive information through lecture to a format in which they were accountable for using the knowledge gained from their instructional videos to work with other students on in-class activities (Goodwin & Miller, 2013; Roshan & Roshan, 2012; Ziegelmeier & Topaz, 2015). Finally, the flipped classroom model increased student engagement with the content, since students were no longer simply working several problems of the same type for practice, but were instead interacting with one another to apply their knowledge and make sense of the lessons together to complete more active in-class assignments (Clark, 2013; Strohmyer, 2016; Goodwin & Miller, 2013; Ziegelmeier & Topaz, 2015).

Study findings did not provide simple, tidy conclusions, but rather yielded mixed and evolving responses on the part of student participants regarding the action research

question concerning student perceptions of the flipped model. On the questionnaire distributed at the midpoint of the unit, students indicated disinterest in the teaching strategy, and suggested an addition to the model to include time at the beginning of class for review of the previous night's instructional video. That change was made to the model for the duration of the unit. During the focus group at the conclusion of the unit, five of the participants reported feeling initial apprehension about the model, as a result of their inexperience with it. But students reported that by the end of the unit, they had gained confidence in their learning with the flipped model strategy and expressed a willingness to experience future lessons through a modified flipped model. Focus group responses also included expressions of a preference for teacher-made videos in place of online sources, input that was incorporated into the development of the action plan for the next phase of the inquiry.

The teacher-researcher created a PowerPoint presentation to share findings from the first study phase with the mathematics teachers at EHS and with the district mathematics instructional specialist. The school's two calculus teachers indicated an interest in creating units that use the flipped strategy during June 2018 in-service days. The second phase of the action research will include individual plans for the teacher-researcher to continue investigating a modified flipped classroom model as a means for increasing active, student-centered teaching strategies based on constructivist principles in April 2018 with a calculus unit on volumes. The data from both research phases will be shared at a round table discussion in June 2018 with EHS mathematics department personnel, school administration, and the district mathematics instructional specialist. Mathematics teachers will use in-service time to work in common subject-matter learning

communities to develop videos and in-class activities to be implemented in the 2018-2019 school year. As a professional learning community, the mathematics department will continue to work together toward best practices to improve classroom culture.

References

Adler, M.J. (1988). *Reforming education: The opening of the American mind*. New York, NY: Macmillian.

American Association of University Women Educational Foundation. (1998). *Gender gaps: Where schools still fail our children.* Washington, DC: American Association of University Women Educational Foundation. Retrieved from https://files.eric.ed.gov/fulltext/ED534534.pdf

Aronson, N., Arfstrom, K., & Tam, K. (2013). Flipped learning in higher education. Retrieved from https://flippedlearning.org/wp-content/uploads/2016/07/ HigherEdWhitePaper-FINAL.pdf

Ash, K. (2012). Educators evaluate flipped classrooms. *Education Week*. *32*(2), 6-8. Retrieved from http://cetis58.net/media/nfiles/2014/05/ user_2_ 20140520165338.pdf

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. Eugene, OR: International Society for Technology in Education. Retrieved from https://www.liceopalmieri.gov.it/wp-content/uploads/2016/11/ Flip-Your-Classroom.pdf

Berrett, D. (2012, February 19). How 'flipping' the classroom can improve the traditional lecture. *The Chronicle of Higher Education*. Retrieved from https://people.ok.ubc. ca/cstother/How_Flipping_the_Classroom_Can_Improve_the_Traditional_Lectur e.pdf

Bishop, J. & Verleger, M. (2013, June). *The flipped classroom: A survey of the research*. Paper presented at the 120th ASEE Annual Conference & Exposition. American Society for Engineering Education, Atlanta, GA. Retrieved from https://peer.asee.org/the-flipped-classroom-a-survey-of-the-research

Boaler, J. (2002). Paying the price for "sugar and spice:" Shifting the analytical lens in equity research. *Mathematical Thinking and Learning*, 4(2-3), 127-144. Retrieved from http://mathedseminar.pbworks.com/w/file/fetch/91852809/Jo%20Boaler%20-%20Paying%20the%20price%20for%20sugar%20and%20spice.pdf

Bobbitt, F. (1918). *The curriculum*. Boston, MA: Houghton Mifflin Company.

Bottge, B., Ma, X., Gassaway, L., Toland, M., Butler, M., & Cho, S. (2014). Effects of blended instructional models on math performance. *Exceptional Children*, *80(*4), 423-437. Retrieved from http://ecx.sagepub.com/content/80/4/423.short

Brame, C., (2013). *Flipping the classroom*. Vanderbilt University Center for Teaching. Retrieved from http://cft.vanderbilt.edu/guides-sub-pages/flipping-the-classroom/

Brown, R., Ernst, J., Clark, A., DeLuca, B. & Kelly, D. (2017). Engaging females in STEM: Despite students' actual abilities in STEM, their self-perceptions can be the ultimate deciding factor in what courses they choose to pursue. *Technology & Engineering Teacher, 77*(3), 29-31. Retrieved from https://www.thefreelibrary.com/Engaging+females+in+STEM%3A+Despite+students%27+actual+abilities+in+STEM%2C...-a0514725504

Bruner, J. (2013). Man: A course of Study. In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader*, 4th ed. New York: Routledge. (Original work published 1966).

Center for Research on Learning and Teaching. (2016). Introduction to active learning. Retrieved from http://www.crlt.umich.edu/tstrategies/tsal

Chen, S-C, Yang, S.J.H, & Hsiao, C-C. (2016). Exploring student perceptions, learning outcome and gender differences in a flipped mathematics course. *British Journal of Educational Technology. 47*(6), 1096-1112. Retrieved from https://pdfs. semanticscholar.org/f9d4/5f3e5c67b3d9bca1ad4c1b70d3b8533aa9be.pdf

Clark, K.R. (2013). *Examining the effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom: An action research study* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3592584).

College Board. (2016). AP Central. Retrieved from https://secure-media.collegeboard.org/digitalServices/pdf/ap/ap-calculus-ab-and-bc-course-and-exam-description.pdf

Courant, R., & Robbins, H. (1996). *What is mathematics? An elementary approach to ideas and methods*. (2nd ed.). New York, NY: Oxford University Press. (Original work published in 1941.) Retrieved from https://yakovenko.files.wordpress.com/ 2009/11/cr.pdf

Coursera - Free Online Courses From Top Universities. (n.d.). Retrieved from https://www.coursera.org/about/

Dana, N. & Yendol-Hoppey, D. (2014). *The reflective educator's guide to classroom research* (3rd edition). Thousand Oaks, CA: Corwin.

Day, A., & Foley, J.D. (2006). Evaluating a web lecture intervention in a human–computer interaction course. *IEEE Transactions on Education*, *49(*4), 420–431.

Dewey, J. (1938). *Experience and education*. New York, NY: Simon & Schuster

Dewey, J. (2013). My pedagogic creed. In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader,* 4th ed. New York: Routledge. (Original work published in 1929.)

Dwyer, S.C., & Buckle, J. (2009). The space between: On being an insider-outsider in qualitative research. International Journal of Qualitative Methods, 8, 54-63. doi:10.1177/160940690900800105

Educause. (2016). Massive open online course. Retrieved from https://library.educause.edu/topics/teaching-and-learning/massive-open-online-course-mooc

Eisner, E. (2013). What does it mean to say a school is doing well? In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader*, 4th ed. New York: Routledge. (Original work published in 2001.)

Ferrance, E. (2000). *Action research*. Providence, RI: Northeast and Islands Regional Education Laboratory at Brown University. Retrieved from https://www.brown.edu/academics/education-alliance/sites/brown.edu.academics.education-alliance/files/publications/act_research.pdf

Flipped Learning Network. (2014). *What is flipped learning?* Retrieved from http://www.flippedlearning.org/cms/lib07/VA01923112/Centricity/Domain/46/FLIP_handout_FNL_Web.pdf

Fusch, P.I. & Ness, L.R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report. 20*(9), 1408-1416. Retrieved from http://nsuworks.nova.edu/cgi/viewcontent.cgi?article=2281&context=tqr

Goodwin, B., & Miller, K. (2013). Research says / Evidence on flipped classrooms is still coming. *Technology-Rich Learning, 70*(6), 78-80. Retrieved from http://www.ascd.org/publications/educational-leadership/mar13/vol70/num06/Evidence-on-Flipped-Classrooms-Is-Still-Coming-In.aspx

Greene, M. (2013). Curriculum and consciousness. In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader*, 4th ed. New York: Routledge. (Original work published in 1971.)

Gross, G. (2014, May 16). How boys and girls learn differently. *The Huffington Post.* Retrieved from http://www.huffingtonpost.com/dr-gail-gross/how-boys-and-girls-learn-differently_b_5339567.html

Hadman, N., McKnight, P., McKnight, K., & Arfstrom, K. (2013). *A white paper based on the literature review titled a review of flipped learning*. Retrieved from https://flippedlearning.org/wp-content/uploads/2016/07/WhitePaper_FlippedLearning.pdf

Hanna, G. (2008). Reaching gender equity in mathematics education. *The Educational Forum, 67*(3), 204-214. Retrieved from https://www.researchgate.net/publication/249053653_Reaching_Gender_Equity_in_Mathematics_Education

Hermann, S.D., Adelman, R.M., Bodford, J.E., Graudejus, O., Okun, M.A, & Kway, V.Y. (2016). The effects of a female role model on academic performance and persistence of women in STEM courses. *Basic & Applied Social Psychology,*

38(5), 258-268. doi:10.1080/01973533.2016.1209757

Herr, K., & Anderson, G. L. (2005). *The action research dissertation: A guide for students and faculty.* Thousand Oaks, CA: Sage Publications.

Herreid, C., & Schiller, N. (2013). Case studies and the flipped classroom. *Journal of College Science Teaching*. *42*(5), 62-66. Retrieved from http://archive.aacu.org/pkal/regionalnetworks/documents/CRWG-SPEE-REF-01.pdf

Hirsch, J. (2014, October 21). "Fliperentiated" instruction: How to create the customizable classroom. *Edutopia*. Retrieved from https://www.edutopia.org/blog/fliperentiated-instruction-create-customizable-classroom-joe-hirsch

Horn, M. (2013). The transformational potential for flipped classrooms: Different strokes for different folks. *Education Next,* 13(3)*,* 78-79. Retrieved from http://educationnext.org/files/ednext_XIII_3_whatnext.pdf

Johnson, G.B. (2013). *Student perceptions of the flipped classroom*. (Unpublished master's thesis). The University of British Columbia, Okanagan, Canada.

Johnson, R. L., & Morgan, G. B. (2016). *Survey scales: A guide to development, analysis, and reporting*. New York, NY: The Guilford Press. doi: 10.1111/fcsr.12226

Knight, J.K., & Wood, W.B. (2005). Teaching More by Lecturing Less. *Cell Biology Education*, *4*(4), 298-310. doi:10.1187/05-06-0082

Lage, M., Platt, G., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *Journal of Economics Education, 31*(1), 30-43. Retrieved from https://maliahoffmann.wikispaces.com/file/view/inverted+classrm+1.pdf

Laursen, S.L., Hassi, M., Kogan, M. & Weston, T. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education*, *45*(4), 406-418. Retrieved from http://jwilson.coe.uga.edu/EMAT7050/articles/LaursenEtAl(2014).pdf

McCrea, B. (2010, September). Engaging girls in STEM. *T.H.E. Journal, 37*(6). Retrieved from https://thejournal.com/Articles/2010/09/08/Engaging-Girls-in-STEM.aspx?Page=1

McGivney-Burelle, J. & Xue, F. (2013). Flipping calculus, *PRIMUS*, *23*(5), 477-486. doi:10.1080/10511970.2012.757571

McLaughlin, J.E., Roth, M.T., Glatt, D.M. Gharkholonarehe, N., Davidson, C. A., Griffin, L.M., … Mumper, R. J. (2014). The flipped classroom: A course redesign to foster learning and engagement in a health professions school. *Academic Medicine*, *89*(2), 1-8. doi:10.1097/ACM.0000000000000086

McMahon, M., & Pospisil, R. (2005). Laptops for a digital lifestyle: Millenial students and wireless mobile technologies. Paper presented at the Ascilite 2005 Conference, Brisbane, Australia. Retrieved from http://www.ascilite.org/conferences/brisbane05/blogs/proceedings/49_McMahon%20&%20Pospisil.pdf

Mertler, C.A. (2014). *Action research: Improving schools and empowering educators*. (4th ed.). Los Angeles, CA. SAGE Publications.

Mills, G. (2014). *Action research: A guide for the teacher researcher.* (5th ed.). Boston, MA. Pearson Education, Inc.

MIT OpenCourseWare: Massachusetts Institute of Technology. (2016). Retrieved from http://ocw.mit.edu/about/

Murray, D., Koziniec, T., & McGill, T. (2015). Student perceptions of flipped learning. In Proceedings of the 17th Australasian Computing Education Conference (ACE 2015), Sydney, Australia. 57-62.

National Council of Teachers of Mathematics. (2009). *Focus in high school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics Commission on Standards for School Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA. Retrieved from http://www.fayar.net/east/teacher.web/math/standards/Previous/CurrEvStds/index.htm

Noddings, N. (1990). Chapter 1: Constructivism in mathematics education. *Journal for Research in Mathematics Education. Monograph, 4*, 7-18, 195-210. doi:10.2307/749909

Noddings, N. (2013). Curriculum for the 21st century. In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader*, 4th ed. New York: Routledge. (Original work published in 2007.)

Noddings, N. (2013). The false promise of the paideia: A critical review of the paideia proposal. In D.J. Flinders & S.J. Thornton (Eds.), *The Curriculum Studies Reader,* 4th ed. New York: Routledge. (Original work published in 1983.)

Overmyer, G.R. (2014). *The flipped classroom model for college algebra: Effects on student achievement* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses database. (UMI No. 3635661).

Palincsar, A.S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology 49*(1). 345-375. Retrieved from http://gsueds2007.pbworks.com/f/Palinscar1998.pdf

Pearson Education, Inc. (2013). *Flipped learning model increases student engagement and performance*. Retrieved from http://assets.pearsonschool.com/asset_mgr/current/201320/Byron_standalone_casestudy.pdf

Piaget, J. (1952). *The origins of intelligence in children.* New York, NY: International Universities Press, Inc.

Prince, M. (2004). Does active learning work? A review of the research. Journal of Engineering Education, 93(3), 223-231. Retrieved from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Prince_AL.pdf

Renfro, A. (2014). *Assessing the effects of a flipped classroom approach on mathematical thinking, attitudes, and teacher perceptions in an undergraduate calculus class using a participatory action research approach* (Doctoral dissertation). Retrieved from ProQuest Dissertation and Theses Global. (Order No. 3733912.)

Roehl, A., Reddy, S.L., & Shannon, G.J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning strategies. *Journal of Family & Consumer Sciences*, *105*(2), 44-49. doi:10.14307/JFCS105.2.12

Roshan, S., & Roshan, W. (2012, August 24). My View: It's never too late to begin flipping your classroom. Retrieved from http://schoolsofthought.blogs.cnn.com/2012/08/24/my-view-its-never-too-late-to-begin-flipping-your-classroom/

Schaffhauser, D. (2017, October). Seven ways to get more girls & women into STEM. *T.H.E. Journal, 49*(9). Retrieved from https://thejournal.com/Articles/2017/10/02/7-Ways-to-Get-More-Girls-and-Women-into-STEM.aspx?s=the_nu_051017&Page=1

Sergiovanni, T.J. (1994). Building Community in Schools. San Francisco, CA: Jossey-Bass.

Strayer, J.F. (2007). *The effects of the classroom flip on the learning environment: A comparison of learning activity in a traditional classroom and a flip classroom that used an intelligent tutoring system* (Doctoral dissertation). Ohio State University, Columbus, OH. Retrieved from https://etd.ohiolink.edu/!etd.send_file?accession=osu1189523914&disposition=inline

Strohmyer, D. (2016). *Student perceptions of flipped learning in a high school math classroom.* (Doctoral dissertation.) Retrieved from http://scholarworks.waldenu.edu/cgi/viewcontent.cgi?article=3281&context=dissertations

Stigler, J. & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York, NY: Free Press.

Swan, K. (2009). Introduction to the special issue on blended learning, Part 1: Blended learning at the class level. *Journal of the Research Center for Educational Technology*, *5*(1), 1-3. Retrieved from https://www.researchgate.net/publication/50806592_Introduction_to_the_Special_Issue_on_Blended_Learning_Part_II

Takacs, D. (2003). How does your positionality bias your epistemology? *Thought & Action*, *19*(1), 27-38. Retrieved from http://www.nea.org/assets/img/PubThoughtAndAction/TAA_03_04.pdf

Talbert, R. (2012). Inverted classroom. *Colleagues*, 9(1) 1-3. Retrieved from http://scholarworks.gvsu.edu/colleagues/vol9/iss1/7

Tedlock, B. (2000). Ethnography and ethnographic representation. In N. K. Denzin & Y. S. Lincoln (Eds.) *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Turner, P. (1995). An overview of feminist perspectives as they relate to science and mathematics education. *he Mathematics Educator, 6*(1), 3-7. Retrieved from http://tme.journals.libs.uga.edu/index.php/tme/article/view/51/43

U.S. Department of Education. (2012, June). Gender equity in education: A data snapshot. Retrieved from U.S. Department of Education, Office of Civil Rights: https://www2.ed.gov/about/offices/list/ocr/docs/gender-equity-in-education.pdf

Voigt, M. (2016, March). Comparative analysis of learning gains and students' attitudes in a flipped precalculus classroom. Paper presented at the First Conference of the International Network for Didactic Research in University Mathematics, Montpellier, France. Retrieved from https://hal.archives-ouvertes.fr/hal-01337919/document

Vygotsky, L. (1978). Interaction between learning and development. In Gauvain & Cole (Eds.) *Readings on the Development of Children.* New York, NY: Scientific American Books. pp. 34-40.

Walliman, N. (2005). *Your research project: A step-by-step guide for the first-time researcher*. (2nd ed.). London, UK: Sage Publications.

Wasley, P.A. (1992). Working together: Teacher leadership and collaboration. In C. Livingston (Ed.), Teacher leaders: Evolving roles (pp. 21-55). Washington, DC:

National Education Association. Retrieved from file:///Users/tammy.parham/Desktop/Wasley.pdf

Wiest, L.R. (2014, July). Strategies for educators to support females in STEM. University of Nevada, Reno, NV. Retrieved from http://www.unr.edu/girls-math-camp/resources/educators/tips

Wikipedia. (2018, February 14). YouTube. Retrieved from https://en.wikipedia.org/wiki/YouTube

Yin, R. K. (2011). *Qualitative research from start to finish*. New York, NY: Guilford Press.

Ziegelmeier, L. & Topaz, C. (2015). Flipped calculus: A study of student performance and perceptions. *PRIMUS, 25*(9-10), 847-860. doi:10.1080/10511970.2015.1031305

Appendix A: IRB Approval

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER for EXEMPT REVIEW

Tammy Parham
College of Education
Department of Instructions & Teacher Education / Curriclum & Instructions
Wardlaw
Columbia, SC 29208

Re: **Pro00066266**

This is to certify that the research study, "***The Flipped Classroom in the Advanced Placement Calculus Classroom: An Action Research Study***," was reviewed in accordance with 45 CFR 46.101(b)(**1**), the study received an exemption from Human Research Subject Regulations on **4/21/2017.** No further action or Institutional Review Board (IRB) oversight is required, as long as the study remains the same. However, the Principal Investigator must inform the Office of Research Compliance of any changes in procedures involving human subjects. Changes to the current research study could result in a reclassification of the study and further review by the IRB.

Because this study was determined to be exempt from further IRB oversight, consent document(s), if applicable, are not stamped with an expiration date.

All research related records are to be retained for at least three (3) years after termination of the study.

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). If you have questions, contact Arlene McWhorter at arlenem@sc.edu or (803) 777-7095.

Sincerely,

Lisa M. Johnson
IRB Assistant Director

Appendix B: Letter to School Administration

PERMISSION FORM: COUNTY PUBLIC SCHOOLS

August 1, 2017

Dear Mr. :

As a graduate student in the Education Department of the University of South Carolina, I am conducting action research as part of the requirements for a Doctoral Degree in Education (Ed. D). The title of my action research project is "An Action Research Study of Female Students' Perceptions of the Flipped Classroom Model in Advanced Placement (AP) Calculus". The purpose of my research is to improve my teaching practices toward more student-centered methods using active learning strategies such as the flipped classroom in the AP classroom.

I am writing to request your permission to conduct my research in York County Public Schools at Clover High School in the AP Calculus classrooms. The study will use a phenomenological research design. I assure you this is not an experiment; I am merely investigating teaching strategies and collecting data to analyze to determine the effectiveness of the strategies used as part of my normal teaching duties.

Participants will be drawn from an AP Calculus class. For the unit on Limits, I will "flip" the classroom by allowing students to acquire content at home (via teacher made videos, YouTube videos, or any other media which contain the content to be learned by the students (I will provide all media)) and return to the next class period to further discuss these concepts, complete homework, or extend learning through further investigation or application problems.

I will be the sole individual involved in data collection. Data will be collected using classroom observations, field notes, a questionnaire, and a focus group discussion. I will analyze the data and use the results to reflect on the opinions of the female students about the Flipped Classroom teaching methodologies employed in the action research study. Participants will be presented with informed consent information prior to participating. Having her responses be a part of this study is completely voluntary and participants are welcome to discontinue participation at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on approved letterhead indicating your approval.

Sincerely,

Tammy L. Parham
Master of Mathematics
University of South Carolina Doctoral Student
_____ High School Mathematics Teacher

Appendix C: Letter to Parents of Participants

Informed Consent and Assent Form

Principal Investigator: Tammy Parham
Project Title: A Study of Students' Perceptions the Flipped Classroom Model in Advanced Placement (AP) Calculus

Dear Select Parents/Guardians and Students,

As a graduate student in the School of Education at the University of South Carolina, I am conducting action research as part of the requirement for a Doctoral Degree in Education. The title of my action research project is "An Action Research Study of Students' Perceptions the Flipped Classroom Model in Advanced Placement (AP) Calculus". The purpose of my research is to evaluate student perceptions of the Flipped Classroom implementation in the AP Calculus classroom, particularly for female students. This letter is an invitation to participate in my study. I assure you this is not an experiment; I am merely studying the experiences of the students with the Flipped teaching strategies and collecting data to analyze in order to determine the opinions about the strategies used as part of my normal teaching duties.

The Calculus unit on Limits will be used for investigation with the Flipped teaching methods. In the Flipped Classroom, student-participants will acquire content outside of the class time (via teacher made videos, YouTube videos, or any other media which contain the content to be learned by students) and return to the next class period to further discuss these concepts, complete practice and/or extend learning through further investigation or application problems. I will record my observations during class of the students' interactions with one another, the teacher, and the content material. I plan to administer a questionnaire to gain insight in to the attitudes of the students during the unit on Limits. Also, a focus groups will be used to better give voice to the female students experiences with the Flipped Classroom Model. There are no foreseeable risks to the students involved. Participation will be completely confidential and no personal, identifying information will be revealed when analyzing the data or presenting the results. Having student's responses be a part of this study is completely voluntary and participants are welcome to discontinue participation at any time. I will share the results with the participants and use the information to reflect on my own teaching practices and to advise for future instruction in my classroom and others in order to provide a more equitable environment in mathematics for female students.

To participate, please review, sign, and return to me the informed consent/assent below so that I can note your approval to participate in this study.

Thank you in advance for your participation. If you have any questions about the study, you can contact me at 803-810-8200.

Sincerely,

Tammy L. Parham
Master of Mathematics
University of South Carolina Doctoral Student
_____ High School Mathematics Teacher

YES. As a parent/guardian, I understand the study and give my consent for my student's responses to be analyzed and included in the study and for my student's participation in a focus group.	NO. As a parent/guardian, I understand the study and do not give my consent for my student's responses to be analyzed and included in the study or for my student's participation in a focus group.
Parent Name: Parent Signature:	Parent Name: Parent Signature:

YES. As a student, I understand the study and give my assent for my responses to be analyzed and included in the study and for my participation in a focus group.	NO. As a student, I understand the study and do not give my assent for my responses to be analyzed and included in the study or for my participation in a focus group.
Student Name: Student Signature:	Student Name: Student Signature:

Appendix D: Observations and Field Notes

Date: _____

Checklist-Flipped Classroom Model

Student	Watched Videos Prior To Class	Took Notes From Videos	Copied Examples From Videos	Wrote Clarifying Questions From Videos	Participated In Collaborative Practice In Class	Additional Observations/ Comments

Field Notes:

Reflections/Comments:

Appendix E: Student Questionnaire

Student Perceptions of the Flipped Classroom Model

I. Rate each item on the scale provided to indicate your level of agreement.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1. The Flipped Classroom gives me greater opportunities to communicate with other learners.	☐	☐	☐	☐	☐
2. The Flipped Classroom instruction is more engaging than traditional classroom instruction.	☐	☐	☐	☐	☐
3. I like watching the lessons on video.	☐	☐	☐	☐	☐
4. I am spending less time on traditional math homework.	☐	☐	☐	☐	☐
5. I regularly watch the video assignment.	☐	☐	☐	☐	☐
6. I would rather watch a teacher led lesson than a video lesson.	☐	☐	☐	☐	☐
7. The Flipped Classroom gives me less class time to practice math.	☐	☐	☐	☐	☐
8. I am more motivated to learn math in the Flipped Classroom.	☐	☐	☐	☐	☐
9. I would not recommend the Flipped Classroom to a friend.	☐	☐	☐	☐	☐

10. The Flipped Classroom improved my learning of mathematics.	☐	☐	☐	☐	☐

Rate each item on the scale provided to indicate your level of agreement.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
11. I would like to continue implementing the Flipped Classroom with some future units/lessons.	☐	☐	☐	☐	☐
12. I feel sufficient opportunity was provided to ask questions to the teacher for clarification during the Flipped Classroom Model.	☐	☐	☐	☐	☐
13. I explored my own strategies for learning.	☐	☐	☐	☐	☐
14. I am more responsible for my learning in a Flipped Classroom setting	☐	☐	☐	☐	☐
15. I am more engaged with the content in a Flipped Classroom setting.	☐	☐	☐	☐	☐
16. The Flipped Classroom provided more opportunity to collaborate with other learners.	☐	☐	☐	☐	☐
17. One-on-one interaction with my teacher increased during the Flipped Classroom.	☐	☐	☐	☐	☐

II.

18. What would you consider to be the advantages of the Flipped Classroom?

_____

_____

19. What would you consider to be the disadvantages of the Flipped Classroom?

_____

_____

20. What adjustments would you recommend to improve learning in the Flipped Classroom?

_____
_____
_____

Appendix F: Focus Group Sample Prompts

The following prompts were used to guide the focus group session that was used to discover the perceptions of the female student-participants about the Flipped Classroom Model.

1. Describe your learning experience during the Flipped Class Model.
2. What did you think of the Flipped Classroom structure?
3. How did you feel about your learning with the Flipped Classroom structure?
4. What is your opinion about continuing future lessons with the Flipped Classroom structure?
5. Is there anything else you would like to say about why you support or do not support the Flipped Classroom?

Appendix G: Samples of Videos Used for Flipped Lessons on Limits

Take notes and be prepared to ask questions in class

Limits Notation and understanding & Evaluating Limits graphically and by table

Watch the video from the following link from 39:00 min to 1:27 min

https://www.youtube.com/watch?v=54_XRjHhZzI&index=5&list=PLF797E961509B4EB5 (Links to an external site.)

Evaluating Limits Analytically at a point and "infinity"
Substitution & Factoring

Evaluating Limits Part 1: 0-8:07

https://www.youtube.com/watch?v=kuNVeNtovyo (Links to an external site.)

Evaluating Limits Part 2: 14:45-22:09

https://www.youtube.com/watch?v=txiybVb6zO0 (Links to an external site.)